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② ANNUAL REPORT OF THE  
NATIONAL RESEARCH PROGRAMS  
1978

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## FOREWORD

### Crop Production

Research under Program Element 677, Crop Production Efficiency Research, includes research under 15 National Research Programs (NRP) in Crop Production and 2 Special Research Programs (SRP).

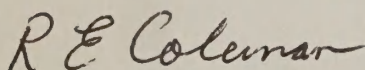
Research is conducted to improve plant productivity through improved varieties of food, feed, fiber, forage, florist and nursery crops, and turf to develop new crop resources and to develop improved crop production practices. Current emphasis is on research to develop new genetic stocks and varieties, increase yields and quality of crops, improve mechanization and crop production practices and to alleviate the effects of adverse environmental conditions through hardier plants.

New multidisciplinary concepts for increasing our productive capacity have been initiated. Special emphasis has been placed on improving basic photosynthetic processes in plants, natural nitrogen-fixing processes in soils and plants, better use-efficiency of both renewable and non-renewable energy resources, and control of plant growth and development.

The research workers in the plant sciences publish the results of their investigations in the open literature as quickly as sound judgment warrants. This is an administrative report to provide for those interested in the results of this work, a brief overview of the scope of the activities and examples of recent findings, some of which still have not been released by publication. No attempt is made at completeness.

This report outlines the research for which the Plant Sciences Staff is responsible and provides a brief description of recent accomplishments at the various locations throughout the United States. The report is organized by SEA National Research Programs, each of which describes a separate subject matter area. The SEA National Research Programs are subdivided into Technological Objectives which more specifically describe the objectives of each area of research.

Readers who have comment or inquiries are invited to contact either the National Program Staff or, more appropriately, scientists at the locations where the research is conducted.



R. E. Coleman  
Acting Chief  
Crop Production

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## SUMMARY

Crop production research is an integral part of the total research program in the Science and Education Administration. Research is conducted to improve plant productivity through improved varieties of food, feed, fiber, forage, florist and nursery crops, and turf to develop new crop resources and to develop improved crop production practices. Current emphasis is on research to develop new genetic stocks and varieties, increase yields and quality of crops, improve mechanization and crop production practices and to alleviate the effects of adverse environmental conditions through hardier plants. New multidisciplinary concepts for increasing our productive capacity have been initiated. Special emphasis has been placed on improving basic photosynthetic processes in plants, natural nitrogen-fixing processes in soils and plants, better use-efficiency of both renewable and non-renewable energy resources, and control of plant growth and development.

The research is described under 15 National Research Programs (NRP) and 2 Special Research Programs (SRP).

A brief summary of each NRP and SRP is provided in the front of this volume. More detailed reports for each NRP and SRP follow with selected examples of progress and publications.

NRP 20010 Breeding and Production - Fruits, Nuts, and Specialty Crops

The objectives of this National Research Program are to develop new improved varieties for fruits, nuts, and specialty crops and to develop new improved cultural and management practices for these crops. This research is presently being conducted at 16 locations by 55 scientists in several disciplines and serves many small and diverse horticultural industries. Research reported in this annual summary is also reported in 103 separate scientific articles. This current research includes highlights on (1) introduction of new improved pest-resistant varieties with increased consumer acceptance, (2) genetic studies on mode of inheritance of horticulturally important fruit and plant characteristics, (3) survey information on genetic resources available for use by those conducting breeding programs, (4) improved techniques for applied fruit breeding, (5) cultural practices to increase yields and reduce cost of production, (6) improved methods of disease control, particularly viruses, (7) new rapid procedures for indexing plant material for viruses and virus-like disorders, (8) physiology studies on plant growth, flowering, and fruiting, and (9) new and improved methods of plant propagation.

NRP 20020 Breeding and Production - Vegetables

This program emphasizes research in breeding and production of vegetables to develop new and improved genetic and cultural methods that will result in lowering costs of vegetables and potatoes to consumers and increasing efficiency of production of these crops to growers, small

acreage farmers, and homeowners. Geneticists, plant pathologists, plant physiologists, and horticulturists (both Federal and State) work in a team approach to evaluate and improve vegetables and vegetable cultural methods.

Basic studies on heritability have led to the development of new germplasm or breeding lines that include: a possible new male sterile system for cole crops; a gene for pea seedborne mosaic virus that has been transferred to standard pea varieties; improved flavor in carrots; resistance to seed corn maggot and seedling disease resistance in dry beans, and soil insect resistance in sweet potato. Germplasm releases have been made that will enable other plant breeders to use these breeding lines toward the development of improved cultivars. The releases include: a winter hardy lentil; long dormant onions; resistance to Colorado potato beetle and bacterial wilt in potatoes, and curly top resistance in tomatoes.

Several new varieties were released, all with multiple disease resistance. Mainstream, a new cantaloup, is highly resistant to mildew and cucumber beetles, high yielding and suitable to commercial growers and home gardeners. Potato varieties, Belchip and BelRus, have exceptional processing quality in addition to the multiple disease resistance. Two potato varieties released last year, Atlantic and BelRus, are in big demand all along the eastern seaboard because of their disease resistance and quality. Two new processing tomato varieties, US28 and US141, combine disease resistance with wide adaptability, good yield, excellent firmness, and quality canning traits.

Research on improving cultural practices has shown that the use of off-shoots for planting artichoke fields is superior to the conventional method of crown plantings and saves time and labor. Also with artichoke production, monitoring plume moth egg counts on a weekly basis results in more timely and effective use of insecticides.

#### NRP 20030 Breeding and Production - Florist and Nursery Crops

The major emphasis of this program deals with the multidisciplinary research to develop new technology for improving productivity and increasing efficiency in the production of florist and nursery crops to enhance urban and rural environments. This need for new knowledge makes it essential to provide research results on selecting, improving, protecting, maintaining, and cultivating plants for urban and rural home, landscape, and special purpose plantings such as parks, roadside, and shopping centers. Progress for this year included: the release of two camellias, Ack Scent, a fragrant flowered cultivar, and Frost Prince, a cold hardy cultivar; two hollies, a female Sparkeleberry with outstanding fruitful landscape characteristics, and a male pollinator, Apollo; two evergreen holly hybrids, September Gem and Clusterberry, with dense clusters of glossy fruit, superior for landscape and home planting; and a wilt resistant mimosa, Union, adaptable as far north as Washington, DC.

Another phase of the research deals with improved cultural and management practices that increase yield, minimize losses, and improve quality. A variety of new developments are reported. Guidelines have been developed for nurserymen to select genetically superior red maple seed for lining out, which will lead to better quality trees for consumers. The Japanese Scholar tree has been identified as being tolerant to deicing salt and thus suitable for urban use. Twenty-seven poinsettia cultivars were distinctly separated from each other by their anthocyanin constitution. This type of "fingerprinting" will be helpful in identifying cultivars protected by law. Different supplemental lighting regimes with high and low pressure sodium lamps can help classify greenhouse plants into energy-requiring types and establish lighting practices that will provide maximum growth for the shortest periods before marketing. An improved tree injection system has been developed for use in growth and pest control and as a means of providing supplemental tree nutrition.

Basic research on rhododendron has shown that weevil feeding preference is associated with extractable attractants in susceptible species and extractable inhibitors in resistant species. This knowledge is important in developing pest control strategies. Dutch-elm-disease fungus strains tolerant to benzimidazoles have been identified. Should such strains become widespread, new control measures will be needed.

Another phase of the research involves enhancement of environmental quality by reducing pollution and improving our surroundings. In related research, 74 florist and nursery crops were exposed to a range of ultraviolet light. Very few plants showed any response suggesting that future increases in atmospheric ultraviolet will have little detectable effect on growth of most landscape plants. Plants stressed by air pollution or disease often evolve ethylene. In vitro studies with an ornamental plant pathogen suggest a microbial ethylene synthesis pathway never before described.

#### NRP 20040 Breeding and Production - Corn, Sorghum and Millets

Corn inbred lines released by the cooperative USDA-State programs are widely used in commercial corn hybrids. The inbreds, B73 and M017, were utilized in commercial corn hybrids estimated to have been planted on 7.3 to 8.1 million hectares in 1978 with the main concentration being in the irrigated areas of the Great Plains and the central Corn Belt.

Long-term recurrent selection programs with maize are being conducted on several populations of normal corn and in two populations involving yield and protein content and quality. The impact of breeding populations on commercial breeding programs is not known, but the requests for seed allotments indicate commercial breeders are aware of their possible potential for line development.

Work to broaden the genetic base for maize breeding continues at a number of locations. This cooperative effort is concentrating on screening exotic races for pest resistance and general agronomic traits of interest in the breeding programs. Six of these racial collections have been chosen for use in population improvement programs for the future.

Through the use of genetic marking and x-ray induced mutations, work has shown that the dormant embryo of maize contains 2-4 cells destined to become tassel tissue and 2-4 cells destined to become ear tissue but no connection between these two sets of cells. This knowledge of developmental mechanics provides a foundation for devising optimum time strategies in cultural practices as well as for basic understanding of the process of development.

Sprinkler irrigation gradient proved to be an effective method of selecting sorghum genotypes for yield stability to drought stress. Yield reductions from wet to dry side ranged from 15 to 74% among advanced agronomic hybrids.

#### NRP 20050 Breeding and Production - Small Grains

Primary emphasis is placed on basic and applied research directed toward improvement of varieties of wheat, oats, barley, and rice, so that new varieties will produce more grain per acre, will have more effective protection from diseases and insects, will be able to withstand environmental adversities, and will produce better quality and more nutritious grain for food and feed.

In 1978, wheat was grown on 66,000,000 acres, oats on 16,385,000 acres, barley on 9,987,000 acres, and rice on 3,080,000 acres in the U.S. Rye was grown on an additional 2,985,000 acres and very small acreages of triticale, wild rice, and buckwheat were produced. All are included in NRP 20050.

#### NRP 20060 Breeding and Production - Cotton

The mission is to develop new knowledge which will increase production efficiency and provide consumers with a stable supply of fiber and food at a reasonable cost. Research approaches emphasize genetic improvement and the development of more efficient cultural and management practices. The research is conducted at 15 locations across the Cotton Belt and involves about 50 scientists. Special emphasis is being given to developing adapted germplasm with resistance to insects and diseases. Thirty-five breeding stocks were released with partial resistance to insect pests including bollworms, budworms, boll weevils, Lygus and whiteflies. Three additional stocks were distributed with resistance to root-knot nematodes and Fusarium wilt. Progress is continuing on the conversion of wild cottons which flower only in the tropics to day-neutral types which flower in the Cotton Belt. Eighty-one converted lines were released and represent important progress in broadening the germplasm base for cotton improvement. Over 1,300 accessions in the Regional germplasm collection were evaluated for various seed characteristics, including oil percentage. This information is useful to public and private scientists interested in improving cottonseed quality for food and feed. Basic studies on genetic and cultural methods for improving drought tolerance and water use efficiency in cotton are being continued in the High Plains and the irrigated West. Research on alternative management systems for reducing production costs is being

expanded. Variables include varieties of differing maturity, plant spacing, fertility levels, water management and growth regulators. Shorter season production systems appear especially promising in semi-arid and irrigated areas. Basic research on the biochemistry of pest resistance and the biological control of cotton diseases is providing information for the long-range solution of many pest problems.

#### NRP 20070    Breeding and Production - Tobacco

Tobacco variety influenced sheet formation during homogenized leaf curing of bright tobacco. Out of 31 varieties, six were excellent sheet formers, nine good, eight, fair, and eight, poor. Sheet formation enhances usefulness of homogenized leaf cured (HLC) tobacco. Protein removal during the HLC procedure has a twofold purpose: (1) Preparation of safer tobacco for smoking, and (2) recovery of an edible protein byproduct. Amino acid and composition of Fraction I and Fraction II proteins were similar and rat feeding studies showed them to be similar in nutritional value to protein from milk. Upon combustion these proteins yielded significant amounts of quinoline, HCN, and oxides of nitrogen, all highly undesirable in tobacco smoke.

Nicotine content of leaf - and to a lesser extent, tar content of smoke - are influenced by heredity. In two specially-selected families of breeding lines, seven nicotine levels (0.36% to 3.94%) were identified in one family and six (0.41% to 4.49%) in the other. Among unselected varieties, tar expressed as mg/cigarette ranged from 23.41 in the low variety to 31.55 in the high variety.

Tobacco pest control research showed substantial progress in 1978. New growth regulators to control tobacco suckers, sources of budworm and hornworm resistance, and biocontrol methods for leaf diseases have the potential to control tobacco suckers, diseases, and insects and at the same time reduce unwanted pesticide residues.

A method of transplanting germinated anthers to soil where colchicine-treated plantlets developed roots was superior to the old method of harvesting diploidized plants from the germinating medium. Use of fatty alcohol to control suckers increased costs \$150 per acre over costs when systemic maleic hydrazide was used. Incorporation of resistance to potato virus Y (PVY) into root knot resistant cultivars provided the first evidence that such resistance was effective in overcoming the lethal response of root knot resistant cultivars to necrotic PVY.

Burly tobacco breeding line, Greeneville 102, resistant to PVY, two other virus diseases, three fungus diseases, and a bacterial disease, was released for use by tobacco breeders and growers.

NRP 20080    Breeding and Production - Soybeans, Peanuts, and Other  
Oilseed Crops

Primary emphasis is placed on the improvement of oilseed crops by genetics and breeding and by cultural and management practices. Soybean, peanut, and other oilseeds production research is conducted at 11, 3 and 5 locations, respectively; the total number of locations for oilseeds production research is 17. Approximately 37, 8, and 12 SY's are assigned to soybeans, peanuts, and other oilseeds, respectively, representing the disciplines of plant genetics, agronomy, plant pathology, plant physiology, microbiology, chemistry, entomology, and soil science. Most of the research is highly cooperative with State Agricultural Experiment Stations. The highlights of 1978 included: (1) Cooperative releases of 12 varieties of soybeans ranging in adaptation from the northern U.S. to the Rio Grande Valley, 3 soybean germplasms, and a peanut and a safflower germplasm; (2) An improvement in soybean oil by reduction of linolenic acid from 8 to 4%; (3) Completion of the first step in identifying structural genes for soybean protein; (4) The identification of a wound hormone in plants; (5) The completion of the wild sunflower collection to include all North American species and some success in cultivated x wild sunflower hybridizations; and (6) The development of peanut lines resistant to the aflatoxin producing fungus.

NRP 20090    Breeding and Production - Sugar Crops

Primary emphasis in the program is on improvement of sugar crops through breeding of superior varieties, hybrids, and breeding lines. Secondary emphasis is on developing cultural and management practices to increase sugar and syrup yields, minimize production losses, improve quality attributes, and efficiently conserve scarce resources in production systems involving the three crops. This research is conducted at 10 locations by 38 scientists. Sugarcane is grown on about 300,000 hectares in 4 States, and sugarbeets are grown on 486,000 hectares in 16 States. During the period 1970-78, domestic production provided an average of 58 percent of U.S. sucrose consumption. The remainder was imported from several foreign sugarcane-producing countries. Sweet sorghum is grown for syrup production in several southeastern States and has potential for sugar production, but current world overproduction and subsequent low sugar prices have precluded its use.

The highlights of 1978 research include: (1) Release of two borer resistant high yield sugarcane varieties for production in Louisiana ; (2) Release of 41 breeding lines of sugarbeet with general combining ability for yield and resistance to major sugarbeet diseases in various combinations; (3) Determination that yield potential in Louisiana is two to three times the State average yield when sugarcane is grown in close-spaced rows; and (4) Initiation of an extensive testing program to determine the reaction of mainland varieties to a new, potentially disastrous disease, sugarcane smut. This disease was identified in Florida for the first time on the mainland in June 1978.

NRP 20100 Breeding and Production - Forage Crops for Hay, Pastures  
and Other Uses, Including Turf

Three varieties (one bermudagrass and two Sericea lespedeza) and eight germplasm pools (seven alfalfa and one red clover) were released during 1978. New plant introductions continue to be an important source of genetic variability in forage plants, including buffelgrass, kleingrass, Russian wild ryegrass, wheatgrasses, alfalfa, clovers, and others.

The search for sources of resistance to plant pests and the development of pest-resistant cultivars remain high-priority areas of research. A new strain of anthracnose fungus was isolated in Maryland and North Carolina. The seriousness of the new strain remains to be clarified; however, work has begun to incorporate resistance into available germplasm. Verticillium wilt of alfalfa was first discovered in the United States in 1976 and is now found to be infesting about 50% of the alfalfa acreage in the Pacific Northwest. Development of resistant cultivars is imperative, and an experimental alfalfa cultivar adapted to the Pacific Northwest has been developed with increased verticillium wilt resistance.

The use of tissue culture techniques offers considerable promise in genetic as well as physiological studies. Haploid plants have been obtained from anthers of tall fescue when cultured with nurse tissue of the parent plant. Red clover plantlets have been regenerated through the use of tissue culture techniques. Such research offers promise for reducing the time and expense required to fix characters of economic importance into true breeding lines and cultivars.

The adoption of field-wilting techniques for producing dehydrated alfalfa has increased production as much as 10 to 50% while reducing natural gas usage as much as 10 to 40%. The product has been shown to be of equal value in cattle growth and lamb digestion trials compared to direct-cutting methods.

Perennial forage grasses have been demonstrated as more efficient utilizers of municipal sewage as a growth stimulant compared to corn or alfalfa. Also, forage quality was not adversely affected and actually was enhanced in some instances.

Cattle gains have been enhanced during the hot months of July and August through the use of perennial warm-season grasses, such as caucasian blue-stem and switchgrass, at a number of locations. The maintenance of positive cattle gains on forage alone during the entire grazing season appears possible in many areas.

## NRP 20110 Improved Vegetation and Management Practices for Range

An exciting forage breeding program is underway on the generation of new forage species through wide crossing and induced polyploidy. The hybridization of quackgrass (Agropyron repens) with bluebunch wheatgrass (Agropyron spicatum) appears quite promising for the development of an improved range forage plant. The potential for developing improved legumes with superior seedling drought resistance continues to look good. Two varieties of Lehmann lovegrass, 'Kuivato' and 'Puhuima', and two germplasm pools of cicer milkvetch were released. These releases were developed for persistence under stress environments.

New range improvement practices are being developed and evaluated for increasing range productivity and persistence. Punch planting, mechanical treatment of brush infested ranges, selective herbicide treatment with reseeding, revegetation of coal stripmine spoils, and thinning and sodding of blue grama grass stands are examples of recent developments.

Studies indicate deer populations can be managed on eastern Oregon ranges without a major conflict with livestock production. Fourwing saltbush contributed significantly to the diet of cattle grazing short-grass prairie, particularly during the winter, verifying the value of the species for livestock. The use of forage crops, such as pearl millet and wheat or rye, to complement native range increased cattle weight gains appreciably in the Southern Great Plains. The net return per animal unit ranged from \$140 to \$175 in 1978. Research on the use of modeling for the evaluation of soil-plant-animal systems has been initiated. Results will be helpful in determining economical optimum stocking rates and for economical comparisons of range improvement practices.

## NRP 20160 Introduction, Classification, Maintenance, Evaluation, and Documentation of Plant Germplasm

The thrust of this program is to rescue disappearing germplasm resources from many parts of the world, maintain them in good condition, make them readily available to users who are improving and protecting our crop agriculture, record in retrievable form vast amounts of information on them so that we can be more efficient in their assembly, maintenance, and use, and preserve them for the use of future generations. This research is being conducted in 23 locations, involving approximately 55 SY's.

## NRP 20170 Physiological and Biochemical Technology to Improve Crop Production

This National Research Program coordinates and manages research elucidating the basic function of plants at the physiological and biochemical level. New data resulting from this research **are used** to establish advanced agricultural technology with emphasis on field and horticultural crops. The following are major fields of consequence within NRP 20170:

1. Improve the photosynthetic capability, photosynthetic efficiency, translocation, metabolism, and biological conversion of solar energy of plants.
2. Develop improved efficiency of nitrogen fixation and the absorption, translocation, and utilization of nutrients.
3. Improve crop production under environmental stress and reduce stress damage to plants.
4. Improve technologies for understanding water relations, seed germination, growth regulation, flowering, fruiting, and photoperiod as a base for using molecular biology to increase crop production efficiency.

There are 56.2 SY's engaged in research at 12 locations and supported by approximately \$5.9 million under this National Research Program. The research teams are made up of scientific expertise representing fundamental and applied sciences focused on the optimal transfer of basic information to field application.

#### NRP 20180 Crop Pollination and Honey Production

Best available estimates indicate that there are in the United States about -- 200,000 beekeepers, owning 1-25 colonies of honey bees -- 10,000 beekeepers owning 25-299 colonies of honey bees -- 1,600 beekeepers owning 300 to 30,000 colonies of honey bees.

In total, there are about 4,300,000 colonies kept by beekeepers and many thousands escaped swarms in hollow trees, the walls of houses, caves, etc. There are also about 3,000 species and subspecies of wild (non-*Apis*) bees, mostly solitary rather than social, with three species, the alfalfa leafcutter, Megachile rotundata, the alkali bee, Nomia melanderi, and the orchard bee, Osmia lignaria under man's control for crop pollination purposes. This constitutes the inventory of bees upon which the pollination of \$12-15 billion dollars worth of crops depends for full economic yield and quality. Without this pollination resource we would lose our ability to produce many seed and fruit crops and diversity of food would be drastically reduced. We would also lose many wild flowering plants and live in a markedly different world. In our changing environment we cannot be assured of adequate survival of wild bees or the profitability of beekeeping as an industry. If beekeeping were not profitable it would largely cease to exist. Problems such as inadequate pasture, pesticide losses and diseases confront the long-range survival of bees and beekeeping adequate for pollination requirements.

Research needs include all those associated with major livestock industries plus taxonomic, biological and management studies of wild bees. The basic mission of this national research program is to help ensure the survival of plant pollinators. Projects encompass

such diverse areas as apiary management; bee nutrition, particularly the development of pollen substitutes; control of bee diseases, pests and parasites; easing the persistent and often serious problems of pesticide poisoning; the efficient use of bees for crop pollination; basic bee biology; the taxonomy, biology, usefulness and management of wild bees; the genetic improvement of honey bees, including Africanized bees and studies of apiary products, particularly honey.

#### NRP 20190    Production and Harvesting Equipment and Methods

Equipment and methods are being developed in attempts to solve long-standing and difficult problems in the culture, harvesting, and subsequent farm handling of a variety of horticultural and field crops. Greatest emphasis continues to be on the mechanization of conventional operations which require large inputs of seasonal hand labor, such as fruit and vegetable harvesting. However, emphasis on other important equipment problems, particularly reduction of fossil fuel use and principles of conservation tillage, is increasing. Approximately 45 SY's are involved at 18 locations in 13 States.

The National Program Staff coordinator position is currently vacant and an Annual Report was not prepared.

#### SRP                      Production and Control of Narcotic Plants

This program seeks to affect the production economics of illicit narcotic crops so as to give licit agricultural enterprises a competitive advantage and, secondly, assure that the United States has an adequate and stable supply of raw materials to meet its medical needs for codeine at reasonable cost.

The Department's efforts are designed to be responsive to the perceived needs of the President's program to control drug abuse. International aspects of the program are coordinated through the Department of State, Narcotics Matters; and close liaison is maintained with the Drug Enforcement Administration, Justice Department; the National Institute for Drug Abuse, National Institutes of Health; the Central Intelligence Agency; and the United Nations Narcotics Laboratory, Geneva, Switzerland.

The program is being conducted at 10 locations, involving 5.8 SY's of SEA-AR effort.

#### SRP                      Genetic Vulnerability

The mission of this SRP is to emphasize and coordinate the common concern of 21 parent NRP's and 2 other SRP's to reduce the amount of losses of crops caused by pests and environmental stresses. The commodity programs, the basic plant science programs, the plant germplasm program, and the pest control programs all are intended to lead to the efficient production of high quality, nutritious, safe crops, well adapted to their environments and cultural practices, and so protected from pests and environmental stresses that losses would be held to a

minimum. The program is especially designed to minimize the probability of catastrophic losses **such** as occurred during the southern corn leaf blight epidemic and to enhance the ability to recover quickly from any epidemic that may occur.

No program can reduce the probability of epidemics to zero; however, the approach to lowering the probability, and solving the problem, should one arise, is to have a comprehensive program involving collecting a wide array of genetically diverse germplasm, understanding genetic structure and taxonomy of this material, screening of material for specific useful characters, studying inheritance and breeding behavior of the desirable characters, combining genes from diverse sources into strains more useful to plant breeders, breeding, releasing, and maintaining breeder seed, and producing and distributing high quality planting seed to farmers.

## National Research Program 20010

### BREEDING AND PRODUCTION - FRUITS, NUTS, AND SPECIALTY CROPS

This National Research Program involves research on breeding and production of fruits, nuts, and specialty crops which will result in increased production efficiency for commercial growers, part-time farmers, and homeowners and increased availability, variety, and quality of fruits and nuts for consumers. Where possible, this research is conducted by multidisciplinary teams comprised of horticulturists, geneticists, physiologists, and pathologists and in association with entomologists, nematologists, agricultural engineers, and marketing specialists. The research is intended to be national or regional in scope and to concentrate on long-range projects not easily initiated or justified by individual State Agricultural Experiment Stations.

NPS Contact: Howard J. Brooks

#### Technological Objective 1.

Develop new and improved varieties of fruits, nuts, and specialty crops that combine improved yield potentials; quality characteristics; better resistance to pests; tolerance to environmental stress; and adaptation for mechanical culture, harvesting, and handling.

#### Research Locations:

5202	Fresno, California
5212	Indio, California
7606	Orlando, Florida
7706	Byron, Georgia
1108	Beltsville, Maryland
7404	Poplarville, Mississippi
1305	Chatsworth, New Jersey
3307	Wooster, Ohio
5809	Corvallis, Oregon
7308	Brownwood, Texas

#### Selected Examples of Recent Progress

##### Progress made in grape breeding - Fresno, CA.

Approximately 3,000 grape seedlings from 39 controlled crosses were planted in the field along with an additional 2,600 grape seedlings from 30 crosses for a seedless inheritance study. This year, 66 controlled crosses were made resulting in 19,000 seed. The 30 crosses for the seedless inheritance study were repeated to determine environmental effects. Approximately 6,000 seed resulted from these crosses. Eighteen seedlings were selected from these vines which fruited for the first time and were saved for further evaluation. Six outstanding selections have been propagated and will be planted in the second test plot.

Improved raisin grape selections developed - Fresno, CA. Twenty-five seedless grape selections were dried as raisins. Four appear promising and are being propagated for more tests. The earliest of these selections had 19% soluble solids on July 31, 1978, a full month ahead of Thompson Seedless, the standard raisin grape variety.

New Fiesta raisin grape proves itself - Fresno, CA. The new USDA Fiesta raisin grape variety introduced in 1973 continues to yield as well as Thompson Seedless, the standard variety. In 1978, Fiesta was picked August 22 and was ready to roll when Thompson Seedless was picked August 31. Fiesta was dry when it rained September 4; Thompson Seedless was not dry and was completely ruined by rain.

Grape rootstocks screened for nematode resistance - Fresno, CA. Evaluation of existing rootstock selections was continued and cuttings from 75 grape rootstock varieties and selections were rooted. These were then inoculated in the greenhouse with Meloidogyne incognita and M. javanica and readings taken to determine resistance or susceptibility. These rootstocks will be field tested for resistance to phylloxera this spring. The varieties and selections proving resistant will constitute the primary parent material for the newly emphasized grape rootstock breeding program.

Selections made in stone fruit breeding program - Fresno, CA. One hundred and fifty-six controlled crosses were made and approximately 6,000 seed from these crosses were planted in the greenhouse during November 1978. Approximately 8,800 peach, nectarine, plum, and apricot seedlings were planted in the field in April 1978. In addition, 650 plum and 1,700 peach and nectarine seedlings were successfully grown from early-maturing varieties using embryo culture techniques and planted in the field. Of the fruiting progenies, 55 peach, 27 nectarine, 26 apricot, and 10 plum seedlings were selected during the 1977 fruiting season. One apricot, 3 peach, 14 nectarine, and 8 plum selections are being tested commercially and appear promising as potential varieties.

Tissue culture useful in peach breeding program - Fresno, CA. Ten peach selections were made from a small progeny of 20 seedlings which had been embryo cultured in 1975. Two of these were ripe the first week of May, about 2 to 3 weeks before their parent. This is encouraging since it shows progress can still be made for earlier fruit maturity. Three selections made from a cross for earliness also contain some hardiness and are being tested cooperatively with experiment stations in Northern States.

Hybrid citrus plantings established - Indio, CA. Two standard varieties and 10 promising mandarin X orange hybrids, each on rough lemon and citrange rootstocks, were established in a replicated planting at Indio. Three small tests with plants of the same combinations were placed with cooperators in Arizona and California. This research is the culmination of research started many years earlier.

Cooperative disease resistant citrus rootstock trials continue - Indio, CA. Testing and selection of disease tolerant citrus rootstocks continue. Ten rootstocks show promise for tolerance to Phytophthora root rot and/or tristeza virus. Testing of rootstocks under commercial scions was continued in 11 field plots in Kern, Riverside, San Diego, and Ventura counties on private and government property. At least 8 years of field testing is required before citrus rootstocks might be commercially introduced.

National date palm germplasm repository established - Indio, CA. A national date palm germplasm repository has been established at Indio and is the sole collection of date germplasm available to the domestic and international date industries. Most of the principal commercial date varieties, advanced backcrossed males essential for date breeding, and males with unique metaxenic properties are represented in the collection. This repository is part of a national germplasm repository system for fruit and nut crops.

Promising results from citrus breeding program - Orlando, FL. Twenty-six crosses were made to incorporate burrowing nematode resistance, citrus nematode resistance, Phytophthora resistance, and tristeza resistance in new improved citrus rootstock varieties. Approximately 1,042 seeds from interspecific and intergeneric crosses designed to combine specific rootstock traits were obtained from this year's crosses. The first hybrids of Citrus grandis and C. sinensis with a dwarf clone of Poncirus trifoliata have started to fruit for the first time. Several selections were made for preliminary rootstock tests. In a preliminary test, 179 clones were evaluated for P. parasitica resistance, and 138 clones were evaluated in an advanced test.

Citrus relative used to breed for cold hardiness - Orlando, FL. Young hybrid seedlings of Eremocitrus glauca crossed with C. aurantium, C. sinensis, Fortunella margarita and the parental clones were subjected to natural freeze and controlled freeze tests to study the extent to which the cold hardiness trait of the E. glauca parent might be transmitted. This citrus relative was found to transmit a useful degree of cold hardiness to its offspring and should be considered as a promising source of cold hardiness for the citrus breeding program.

Size control clones sought for citrus industry - Orlando, FL. Feasibility studies were initiated on the use of cytochimerae for tree size control of commercial citrus varieties. Over 90 trees have been propagated from buds derived from colchicine-treated clones. These will be observed for morphological traits indicating the desired chimera type. Natural size control clones would have a considerable impact on the citrus industry.

Citrus relative used to breed new scion varieties - Orlando, FL. Nine hundred and forty-one seeds were harvested from crosses involving Citrus grandis X Poncirus trifoliata backcrossed to P. trifoliata

and from a modified sibcross of (C. sinensis X P. trifoliata) X (C. limon X P. trifoliata). These seeds will be planted and seedlings evaluated to determine if the deciduous characteristic of P. trifoliata can be transferred to Citrus.

Resistance to citrus Alternaria found - Orlando, FL. Progress continues on the evaluation of advanced hybrids for reaction to alternaria disease. Data will be used to determine the best parentage for future hybridization. Under severe disease pressure, 3 advanced test hybrids showed some leaves with alternaria infection but another advanced test hybrid showed no infection in field tests. This definitely establishes the fact that a degree of field resistance to Alternaria has been found.

Radiation treatments reduce seed number in citrus - Orlando, FL. Irradiation treatments were used on 3 citrus varieties to determine their effectiveness in producing seedless fruit. The limited populations of plants derived from irradiated seed showed 1 Duncan plant with seedless fruit and 1 Pineapple orange with seedless fruit. Ten Pineapple trees showed reduced numbers of seed in the fruit. Foster grapefruit trees derived from irradiated budwood showed 1 with seedless fruit and 2 with reduced numbers of seeds. The period from seed irradiation to production of first seedless fruit was 7 years and the plants were still juvenile.

Citrus glycosides considered as potential genetic markers - Orlando, FL. Research was initiated to evaluate flavanone glycosides as potential markers to study genetic inheritance patterns in citrus. The principal flavanone glycosides present in 55 hybrids of Eremocitrus glauca crossed with Citrus aurantium, Citrus reticulata, C. sinensis, and Fortunella margarita were analyzed to determine the pattern of transmission from parent to hybrid. Forty-seven contained the principal glycoside of the male parent, 3 contained only the principal glycoside of the female parent, and 5 contained neither principal glycoside of their parents.

More selections made in peach and nectarine breeding programs - Byron, GA. Over 23,000 cross pollinations were made in 1978 as the stone fruit breeding program continues. Following screening for disease resistance, over 3,500 seedlings were planted for field evaluation. Two peach and 17 nectarine selections were made and distributed to cooperators for further testing.

More emphasis on plum breeding in 1978 - Byron, GA. There was an excellent plum crop on most seedlings of bearing age in 1978. Over 1,760 new seedlings, 533 of which were pre-screened for bacteriosis disease, were set out. Seventeen new 1978 selections were made. Thirty-eight controlled crosses were made of which 18 yielded viable seeds with almost 1,000 seedlings being realized. Male-sterile flowers from seedlings of Frontier lineage were fixed and preserved for cytological study.

Potential new apple varieties selected - Byron, GA. Sixteen new apple selections were made in the summer apple breeding program and show potential as new varieties. Approximately 300 seedlings from 10 controlled crosses were set in field plantings. Eighteen hand-pollinated crosses yielded approximately 1,300 seed. Many seedling trees were eliminated on the basis of nonproductivity, failure to initiate bloom by age 6, mildew Botryosphaeria susceptibility, and high chilling requirements. Progeny 287 (Mollie's Delicious X Andy June), made in 1975, appeared to have a combination of precocity and high quality. The April 1978 freeze killed the 1978 apple crop on seedling trees at Blairsville, GA.

Oil content very variable in individual pecan kernels - Byron, GA. Oil content in pecan kernels was as variable within the pecan variety Moneymaker as among 21 varieties evaluated in 1977. There was a significant positive correlation between yield and refractive index and a significant negative correlation between yield and percent oil on the variety Moneymaker. Irrigation of the variety Moneymaker for the entire growing season and from late June to early July increased the refractive index presumably as a result of yield increase. Irrigation from late July to early September did not affect the refractive index or yield. These results help explain differences in kernel rancidity.

Research started on screening pecan seedlings for scab resistance - Byron, GA. With the objective to screen pecan seedlings for scab resistance, 3,284 seed from select crosses were planted in the field and an irrigation system was installed to increase humidity and promote incidence of disease. Lack of natural scab infection precluded screening for resistance in 1978 but natural infection is expected to occur in future years. Less than 10% of the seedlings are expected to show field resistance. A limited number of seed resulted from crosses made at Brownwood this summer for the 1979 planting. Several thousand seed were also obtained from a natural reciprocal cross between the parents Elliott and Desirable.

Pear psylla resistance found in Europe - Beltsville, MD. There now appears to be a new potential for breeding pear varieties resistant to the insect pear psylla. During a 2 month germplasm collection trip in Eastern Europe, more than 300 samples of pear budwood were collected from domestic varieties with a high degree of resistance to local psylla populations. Following screening for fire blight and psylla resistance at the Plant Introduction Station, Glenn Dale, MD., selections will be incorporated into the pear breeding program.

Resistance to *Fabraea* leaf spot observed in pear - Beltsville, MD. A high degree of resistance to *Fabraea* leaf spot was observed and recorded in hybrids between *Pyrus communis* and *P. calleryana* cultivars. Such resistance will be incorporated into the pear breeding program. Following fruit evaluation of pear seedlings, seedlings are left unsprayed to accentuate natural disease infection. Natural resistance may be found in the psylla disease-resistant plant material collected in 1978 in Europe.

Light transmission to help in pear harvest - Beltsville, MD.

Nondestructive light transmittance measurements, using difference in optical density at 600-740 nm, were found effective for assessing maturity and ripeness of intact pears. This technique should improve the picking, storage, and ripening procedures of pear selections and varieties of the pear breeding program. Experience has shown that it is extremely difficult to know when to pick pear samples for optimum fruit quality and storage characteristics.

Progress being made to develop grapes resistant to black rot disease - Beltsville, MD. Almost 5,500 grape seedlings from 34 progenies of 1977 seed were screened for black rot resistance in 1978. Eleven F<sub>1</sub> Vitis rupestris X cultivar progenies showed variable resistance from zero to 87 percent, average 37.7 percent. Three F<sub>1</sub> V. Berlandieri X cultivar averaged 35 percent resistant. Eleven V. cinerea F<sub>1</sub> crosses ranged from 66 to 100 percent, average 94.4 percent resistant. Two backcross progenies V. vinifera X (cultivar X V. cinerea) showed 15 and 47 (average 35) percent resistance. Two second-backcross progenies from immune first-backcross showed 4.5 and 19 (average 15.3) percent resistance. A second backcross using a resistant parent was completely susceptible. Approximately 2,100 immune seedlings were planted in the nursery. Just over 8,000 seed of 31 crosses were obtained in 1978. Germination in 1979 was poor with only about 1,000 seedlings developing.

Stone fruit breeding shifted to Kearneysville, WV. - Beltsville, MD.

Trees of 12 advanced selections each of peach and plum were propagated for distribution to experiment stations in 1978-79 for adaptation tests. These and 91 additional peach and nectarine cultivars and selections propagated at Beltsville were planted at the Appalachian Fruit Research Station at Kearneysville along with 86 standard cultivars obtained from a commercial nursery. This is the initial planting in the transfer of the stone fruit breeding program to Kearneysville. About 600 apricot seedlings from Italian sources were screened for lateness of blossoming and fruit characteristics. About 500 peach seedlings from crosses of rootstock selections exhibiting various flower color and leaf pigmentation characters were evaluated for genetic segregation of leaf, stem, and flower pigmentation.

Stone fruit germplasm inventory expanded - Beltsville, MD. Key breeders in Europe were recruited to collect data from their individual countries for a combined North American-European inventory of fruit germplasm patterned after ARS-NE-76. Entries are being received and standardized for computerization and eventual revision of ARS-NE-76. This will greatly help breeders on both continents.

Four blueberry varieties introduced - Beltsville, MD. Rabbiteye blueberry clones Premier, Powderblue, and Centurion and highbush blueberry clone Bluechip were introduced as new cultivars from cooperative breeding program with North Carolina. In New Jersey, 122 highbush blueberry selections were made from 7,260 seedlings, 102 selections were made

from 4,152 seedlings in North Carolina and 55 selections were made from 2,500 seedlings in Georgia. Selections originating in New Jersey, Michigan, North Carolina, and Georgia are being propagated for testing in other locations. Blueberry species hybrids were analyzed at both North Carolina and New Jersey and data will be summarized and genetically interpreted in 1979. Over 40 blueberry selections were made at Beltsville following laboratory or greenhouse screening of seedlings for efficient iron uptake or good growth in upland mineral soils.

Disease resistance studies continue in strawberries - Beltsville, MD. In greenhouse screening for Verticillium wilt resistance, 525 of 1,440 strawberry seedlings from 6 crosses showed resistance. Twenty-nine progenies containing 41,550 strawberry seeds were produced at Beltsville for anthracnose screening at Poplarville, Mississippi. Red stele resistant strawberry seedlings (3,500) were sent to New Jersey for evaluation and 700 everbearer strawberries were planted. Virus-free clones were evaluated for trueness-to-type. Tissue culture propagation of strawberries has been initiated. New cultivars were increased by this method for distribution. Fruit rot resistance following seedling screening varied from 6.1% (Pocahontas X Surecrop) to 29.3% (Earliglow selfed). Tentative identification of Phytophthora fragariae fatty acids have been made by GLC-TLC methods and will be verified by capillary column GLC and mass spectrometric analysis.

Blueberry breeding expanded for the Gulf States - Poplarville, MS. Twenty-two plants were selected for further evaluation from the 1975, 1976, and 1977 blueberry seedling nurseries. Criteria for selection included fruit size, color, taste, firmness, ripening date and yield, plus plant growth vigor. Two plants from the wild were selected for use as late ripening, disease resistant germplasm. Selections made in 1978 were propagated vegetatively and grown in pots. Potted selections from 1977 were planted in Hammond, Louisiana; Stone Counte, Mississippi; and Poplarville, Mississippi. Selections made prior to 1977 were evaluated for fruiting and other horticultural qualities.

Strawberry breeding expanded for Gulf States - Poplarville, MS. Nineteen crosses were made at Beltsville, Maryland, from strawberry plants obtained from cooperative SAES. Seed from these crosses were germinated at Poplarville and 8,000 seedlings were grown in the greenhouse under controlled conditions. These seedlings were inoculated with 5 strains of Colletotrichum fragariae isolated by cooperating SAES and screened for anthracnose resistance. Resistant seedlings (5200) were shipped to cooperative SAES (3,000 to North Carolina, 1,000 to Florida, and 800 to Louisiana). Four hundred seedlings were planted at Poplarville. Nineteen seedlings from the 1976 strawberry seedling field at Poplarville were selected for further evaluation. The selections were based on their high resistance to anthracnose, fruit flavor, size, color, firmness, yield, plant growth, plant habit, and vigor.

Fragaria-Potentilla crosses are sterile - Chatsworth, NJ. (In cooperation with the New Jersey Agricultural Experiment Station). Strawberry seedlings from intergeneric crosses between Fragaria X ananassa X Potentilla sp. are completely sterile. The sterility has been cytologically studied and was, in most cases, caused by desynapsis of the chromosome during meiosis. Phenotypically, the seedlings are not maternal in appearance. They are either genuine hybrids or haploids. From the thirteen surviving seedlings, using washed emasculated flowers, one was identified as haploid and two were not determined. Large proportions of the colchicine treated seedlings died and had not reached flowering stage. One of the hybrids proved to be  $2n=10x=70$ . It must have originated by spontaneous doubling of the chromosomes after fertilization.

Pear psylla resistance identified - Wooster, OH. Twelve pear selections which showed resistance to psylla were selected. These selections are advanced two or three generations over most identified sources of psylla resistance and will be used as parents for further crossing. Hybridization of these selections with high quality cultivars offers a solution to the problems of high cost of controlling the psylla with insecticides, rapid build-up of tolerance to insecticides, and the lack of new controls because of the high costs of development of new chemical controls. About 15,000 seeds were obtained from 48,000 emasculations. Approximately 2,643 fruit samples were evaluated and the data computerized in 1978. Data were taken on tree height, width, crotch angle, fire blight, and flowering for all cultivars.

Selections made for strawberry disease resistance - Corvallis, OR. Bench tests identified 3 clones (OR-US 4288, OR-US 4165, and OR-US 4474) as sources of resistance to a field composite of red stele. Two of these clones have F. chiloensis Del Norte in their pedigree. OR-US 4459 appears to have field tolerance to viruses and the progeny of Totem have good tolerance to viruses in the field. Multiple resistance for both red stele and viruses under field conditions is mandatory for commercial production of strawberries in the Northwest.

Strawberry selections for processing - Corvallis, OR. With the objective to develop strawberry cultivars that may be machine harvested and machine capped, 12 selections were made that had usable machine harvested fruit of more than 3 tons per acre and 3 of these exceeded 4 tons per acre. The machine capping of ripe fruit for these 12 selections averaged 77% with a range of 63% - 87%. OR-US 4681 is in expanded tests and OR-US 4682, 4927, and 4930 were very promising. Introduction of one or more of these selections would greatly expand the acreage of processing strawberries in the Northwest.

Improved hop selections made - Corvallis, OR. With the objective to test and select aroma types of hops from the 1976 Cascade nursery, selections from a nursery of crosses on Cascade and males with good storage stability of the resins were made after the second year of field testing. Selections will be planted in a seedless test location in 5 or 10 hill plots. Initial indications are that these selections have improved alpha-acid content, improved storage stability, and good aroma coupled with good yield potential. USDA 21094 and 21095 were found to be susceptible to downy mildew in replicated greenhouse tests contrary to previous field observations. The two lines were dropped from further field testing in the Yakima Valley. Downy mildew was a problem in 1978, particularly in the progeny related to the susceptible cultivar Comet. Cone yields in general were below expectations.

Hop germplasm with high flavor value for beer developed and released - Corvallis, OR. A germplasm line of hops with about double the alpha-acids value of the average of U.S. hop varieties was developed and released. Alpha-acids provide most of the bitterness and some of the flavor in beer. While not important as a new commercial variety because of low yield potential, the new line, USDA-21055, will provide plant breeders with an excellent genetic source of high alpha-acids.

Chemical studies with hops have direct commercial application - Corvallis, OR. The oil content of 163 hop samples representing approximately 150 genotypes was weakly correlated with alpha-acids ( $r = 0.62$ ) but was unrelated to storage stability ( $r = 0.47$ ). The storage stability of 174 samples was unrelated to their lupulin content ( $r = 0.16$ ). The relationship between the cohumulone content of the alpha-acids in 13 samples and the myrcene content of the essential oils of the same genotypes was not significant ( $r = 0.41$ ), and in the opposite direction to popular belief. These results indicate that any of the quality traits examined can probably be bred for independently. A step-wise procedure was developed which separates alpha-acids, beta-acids, iso alpha-acids and hulapones from a QAE sephadex-A-25 ion exchange column by incremental adjustment of acetic acid concentration of the eluant. The procedure has been adopted as official by the American Society of Brewing Chemists.

Irradiation used in spearmint breeding - Corvallis, OR. (In cooperation with Washington State University). Of 52 irradiation-induced mutants of Scotch spearmint field tested for wilt resistance, only a few were superior to the control varieties. The most resistant strain (336-10-74) had 60% healthy plants at harvest compared to 20% or less in the controls. Of 101 strains tested for powdery mildew resistance, 11 were selected for further evaluation. These 11 strains had vigor comparable to Scotch spearmint and even though infected with mildew, did not drop their leaves prior to harvest.

Pecan variety breeding research continues - Brownwood, TX. Fifteen controlled crosses were made in 1978 which yielded 200 seeds. Sufficient pollinations were made to yield about 4 times this number of seeds when compared to previous years. Hot dry weather caused a heavy nutlet drop. Eleven varieties were used as parents, five served as pistillate and staminate parents but none were selfed. Varieties were used that would produce disease resistant, high quality, and yielding selections. Graftwood from the most promising selections was propagated at Brownwood and other locations for adaptability trials. Approximately 2,033 seedlings of known parentage representing crosses made in 1973-1976 were transplanted on the station at a 5'x17½' spacing for fruiting and evaluation. Approximately 1,015 seed resulting from 17 crosses made in 1977 were planted in the greenhouse.

Land purchased for nut germplasm repository - Brownwood, TX. Seventy-nine acres of land have been purchased at Brownwood for the nut repository planned by the National Plant Germplasm Committee. Pecan and other nut germplasm will be preserved in the repository for use by breeders and other scientists.

Aroma-type hops distributed to brewers - Prosser, WA. Thirty hop lines were selected as aroma-types and submitted to Anheuser-Busch, Schlitz, Coors, and Kirin breweries for evaluation as a replacement for imports. Progeny from a cross having Petham Golding as the female parents had excellent quality and agronomic characteristics. Fifteen high alpha selections represent the best agronomic performance from more than 100 lines with more than 10% alpha-acids. These high alpha lines were sent to Miller Brewery and Pfizer for evaluation as an extract hop. All lines selected for advancement were screened for Prunus necrotic ring-spot virus with negative results.

#### Technological Objective 2.

Develop new and improved cultural and management practices for fruits, nuts, and specialty crops that increase yield, minimize production losses, improve quality, and conserve use of natural resources.

#### Research Locations:

5206	Davis, California
5212	Indio, California
7606	Orlando, Florida
7706	Byron, Georgia
1108	Beltsville, Maryland
7404	Poplarville, Mississippi
7402	Stoneville, Mississippi
1305	Chatsworth, New Jersey
5809	Corvallis, Oregon
7708	Clemson, South Carolina
7202	Weslaco, Texas
5806	Prosser, Washington
5803	Wenatchee, Washington

Selected Examples of Recent Progress:

Virus-free grape collection continues to grow - Davis, CA. Over the years, a collection of 735 grape cultivars has been indexed and established. Another 196 cultivars have been imported, subjected to heat treatments to eliminate thermolabile disease agents, and planted in an isolated block for holding and future indexing. These grapes, representing scion and rootstock types of the world's common grape cultivars, form the nucleus of the University of California Foundation Plant Materials Service (FPMS) grape collection. The National Fruit and Nut Germplasm Repository, which is scheduled for Davis, will integrate its facilities with the local service.

Grape fanleaf virus transmission studies - Davis, CA. Fifty-nine separate grape plant leaves, representing both American and European Vitis species and hybrids, have been inoculated with fanleaf-infected buds placed approximately five cm. below healthy St. George indicator buds on a single plant of each line. These replications of each line so inoculated have been planted in a field nursery where they are being observed for the transmission of fanleaf through the wood to the indicator buds. Fanleaf has been mechanically transmitted to herbaceous test plants in order to obtain sufficient virus for the preparation of a high-titre antiserum to be used in serological tests of fanleaf in the different inoculated test lines. Old antisera of fanleaf that were on hand were not sufficiently pure to be used in ELISA tests.

Sources of grape fanleaf virus resistance found - Davis, CA. The indexing of 18 Vitis species and hybrids growing for 10 or more years in soils infested with viruliferous Xiphinema index at the U. S. Horticultural Field Station in Fresno, showed that 8 of the lines - 4 V. rotundifolia, 1 V. doaniana, and 3 hybrids - were still free of fanleaf. Thus clones are potential sources for fanleaf resistance for a grape rootstock breeding program.

Grape indexing methods improved - Davis, CA. Corky bark disease of the United States and stem pitting of Europe are the same grape diseases. An introduction from Italy, which showed stem pitting symptoms when it was examined by a plant pathologist in Italy, transmitted corky bark to LN-33 indicators in California. The corky bark disease can be indexed by grafting on St. George and LN-33 indicators. Strong strains of the disease show symptoms quicker on LN-33 than on St. George but mild strains show more clearly on St. George than on LN-33 during the second year. The tomato ringspot virus, which causes grape yellow vein disease and which has been associated with stem pitting symptoms in other crop plants, is not the causal agent of corky bark. Yellow-vein infected vines neither show corky bark or stem pitting symptoms nor transmit such symptoms in grape indicators. The heat-stable entity that causes corky bark can occasionally be inactivated by heat treatments.

Effect of grape viruses measured - Davis, CA. Healthy buds from three wine grape cultivars have been grafted onto rootstocks that are either healthy, infected with yellow speckle, or infected with corky bark disease to measure the effect of the diseases on production and fruit quality. In older tests on the effect of grape virus diseases on grape production, it was found that leafroll disease reduced the yields and delayed fruit maturity equally whether the disease was introduced through the scion, the rootstock, or both simultaneously. It was also measured for the first time that fanleaf virus significantly reduces not only the quantity of fruit produced on affected vines but the sugar and acid content as well.

Bacterium toxin induces disease symptoms in grapes - Davis, CA. SEA and University of California scientists showed that the bacterium that causes Pierce's disease is widespread in North America where it can be found from California and South Carolina southward into the tropical regions of Central America. The bacterium produces a toxic material on the surface of the culture medium upon which it can be grown in pure culture. An aqueous solution of this toxin produces symptoms of the disease when it is injected into healthy plants. The symptoms develop in the complete absence of any organism. The toxin can be used to test the varietal tolerance of grape cultivars by injecting standardized doses into grape plants or grape tissue cultures. This technique should greatly speed up the testing of grape breeding lines for Pierce's disease resistance.

Phytophthora species implicated in death of fruit trees - Davis, CA. Research on stone fruits showed that 9 different Phytophthora spp are implicated in root and crown rot and death of peach trees in commercial orchards. P. megasperma, P. drechsleri, and P. cryptogea were shown for the first time to play a significant role in the decline and death of peach and almond trees. Seven different Phytophthora spp are also commonly associated with declining and dead cherry trees in California's commercial orchards.

Walnut disease problems identified - Davis, CA. Contrary to the common assumption that wet feet, sour sap, and Amillaria are the major causes of decline and death of walnut trees, research has shown that loss of walnut trees in California's commercial orchards is caused primarily by Phytophthora cinnamomi, P. citricola, P. cactorum, P. megasperma, and 4 additional Phytophthora species. P. cinnamomi, P. cactorum, P. citricola, and Phytophthora spp #1 were more virulent than P. megasperma and other Phytophthora spp to Juglans hindsii - the most common walnut rootstock in California. This proper identification of the causes of root and crown rot in fruit and nut trees will aid development of effective control measures for these extremely destructive and economically important diseases.

Differences found in walnut rootstocks to Phytophthora diseases - Davis, CA. Northern California black walnut is by far more often used as walnut rootstock than Paradox or English walnut seedlings in California's commercial orchards. However, research has shown that Paradox is significantly more resistant than Northern California black rootstock to Phytophthora citricola, P. cactorum, P. megasperma and Phytophthora spp. #1 but contrary to common assumption by horticulturists, tests revealed that English seedling rootstocks are not more resistant than Northern California black to P. cactorum and P. citricola which are responsible for a high incidence of dead trees in a large number of California' walnut orchards. Paradox is the preferred rootstock to both English and black walnut where P. cactorum, P. citricola, P. megasperma, and Phytophthora spp #1 are present in the soil. However, English, black, and Paradox are equally susceptible to P. cinnamomi.

Cause of 50-year-old walnut disease now known - Davis, CA. Research has shown for the first time that blackline disease of walnut is spreading naturally from diseased to healthy walnut trees within commercial orchards. In orchards surveyed during the last 3 consecutive years, the number of infected trees increased by approximately 96%. Research has also demonstrated that blackline is caused by a graft-transmissible agent. Blackline was readily transmitted by bark and graft-wood from diseased to healthy walnut trees. The percentage of transmission in 6 different experiments ranged from 20 to 100% depending on the inoculum source from naturally infected trees. Therefore, blackline is a specific, infectious disease that can spread naturally and is disseminated with propagation material. The assumption in the past 50 years that walnut blackline was an uninfected disorder is perhaps the major factor which resulted in uncontrolled spread and a wide geographical distribution status of this economically important walnut disease.

Same virus causes disease in different stone fruits - Davis, CA. Research has revealed that Prunus stem pitting is widespread and plays a significant role in decline of cherry trees and other stone fruits in California. Cross graft-inoculation of cherry, apricot, Nanking cherry, Lovell peach, Nemaguard, and Mahaleb showed that tomato ring-spot virus can infect and cause pitting in all tested Prunus species regardless of which Prunus species serves as donor. Thus, stem pitting in different stone fruits can be caused by the same virus and it can spread from different species. This finding is very important for control of this disease. The virus is extremely difficult to recover directly from normally infected stone fruits; identification by differential index plants is unreliable and requires large greenhouse space and is time consuming and expensive. Research has strongly suggested that ELISA can be employed effectively in detecting this virus in several stone fruit species. The application of this technique offers a tremendous advantage in that it is reliable and it requires only 2 days to obtain positive diagnosis of a large number of trees as compared to 1 or 2 years to obtain diagnosis on a few trees by previously used methods.

Date tissue culture looks promising - Indio, CA. Tissue culture studies on date palm have led to the production of plantlets that are advanced to the growth chamber stage of development. These plants are expected to become free-living under greenhouse conditions. This research can lead to large scale, rapid production of date plants of desirable male and female varieties needed in the domestic and international date industries. This would revolutionize date production worldwide.

Drought induces cold tolerance in citrus - Orlando, FL. In controlled environment tests on young potted citrus trees, it was found that withholding water was an effective means of increasing survival during freezes warmer than  $-6.7^{\circ}\text{C}$  ( $20^{\circ}\text{F}$ ). Proline accumulation occurred during water stress and proline continues to be implicated in cold hardening of citrus tissues. In certain instances, cold hardiness induced by water stress was similar to cold hardiness induced by low temperature regimes. Apparently, cold hardening can be achieved through different physiological routes.

Sunburst, a new citrus hybrid released - Orlando, FL. Sunburst, a new citrus hybrid of Robinson X Osceola, was selected and recently released to Florida citrus growers. The fruit matures from mid-November to mid-December during a period when there are no Florida tangerines ripening and coincides with the lucrative Christmas market. The fruit is larger than other commercially grown tangerines, highly colored, excellent quality, easily picked, stores well, and has an excellent shelf life. Sunburst performs well on the east coast of Florida where other tangerines have performed poorly.

ELISA technique developed for citrus tristeza virus - Orlando, FL. An enzyme-linked immunosorbent assay technique has been developed for citrus tristeza virus. This 24-hour technique is 100 to 200 times faster than the standard citrus seedling indicator technique, can assay 10 to 20 times more samples with comparable personnel in the laboratory than in a standard greenhouse, is reliable, and allows more rapid tristeza detection in the field. This technique provides new technologies which will greatly facilitate tristeza eradication programs. Currently, laboratories in California and several foreign countries are implementing this technology in their tristeza eradication programs.

New diagnostic technique identifies citrus diseases in Argentina, Uruguay, and Brazil - Orlando, FL. A new citrus blight diagnostic technique has been developed which greatly facilitates blight research. This diagnostic technology depends on the use of visual symptoms, zinc and phenolic analysis of trunk wood, and water infusion rates into the tree trunk. Blight characteristically causes zinc and phenolic accumulation in trunk wood and reduces water infusion rates in the trunk. Until recently, citrus blight was thought to be confined to Florida. But new evidence using this diagnostic technology has identified the disease in citrus industries in Argentina, Uruguay, and Brazil.

Xylem plugging related to citrus blight - Orlando, FL. Research continues to determine the effect of xylem vessel plugging in blight trees on water movement in tissues. Xylem vessel obstructions were found in root, trunk, and limbs of trees with blight but the degree of plugging did not always correlate well with measured water movement in the xylem. Young xylem vessels were more functional than older xylem vessels in trees with blight and healthy ones but the greatest reduction in water movement was in the older vessels in trees with blight. An injection apparatus was developed that allows easy injection (infusion) of solutions into outer wood of citrus trees.

Citrus blight alters energy transport system in trees - Orlando, FL. Research was initiated to determine the effects of blight on the adenosine triphosphate (ATP) levels in citrus tissues. Changes in ATP in blighted and non-blighted citrus were compared and ATP levels were found to be significantly lower in blighted trees. In some cases, the levels were 3 to 5 times higher in healthy over diseased trees before visual symptoms appeared.

Citrus responds to fruit thinning chemicals - Orlando, FL. Research on flower and fruit thinning of young citrus trees showed that single applications of gibberellin at various times during the winter were not effective in reducing flowering of Dancy tangerines. Similar applications on young orange trees to prevent fruiting were inconclusive because of tree-to-tree variability. Ethephon at 250 ppm was effective in thinning young Dancy fruit in April and May. However, thinning in April only removed fruit that normally dropped in May giving only temporary effects. Murcott tangerine fruit were much more sensitive to ethephon than Dancy. Even at 200 ppm, ethephone caused almost total fruit abscission. Leaf drop was near zero on both varieties.

New fungicide effective against citrus foot rot - Orlando, FL. With research to control Phytophthora parasitica with systemic fungicides, 6 field experiments with a systemic fungicide have shown the chemical to be very effective in controlling citrus root and foot rot in the nursery. In all 6 experiments (involving seedlings in a seedbed, lined-out stock in the nursery, budded stock in the ground and in plastic containers), control was highly significant between chemical and check treatments. However, no significance was found between rates of application. Tests for timing applications and residual of the chemical were not conducted.

Lipid content of mycorrhizal roots investigated - Orlando, FL. Research was initiated to evaluate lipid content of mycorrhizal roots as an assay procedure to quantitate mycorrhizal fungi in citrus root tissue. Lipids were purified from roots of 6 citrus rootstock cultivars inoculated with Glomus mosseae. Neutral lipids and coumarins comprised about 75-86%, glycolipids about 8-22%, and phospholipids 2-7% of the

total fat soluble extracts. In general, glycolipids were higher in controls than inoculated cultivars. Phospholipids were higher in all inoculated cultivars and no differences were present in the neutral lipids and coumarin fraction. Three new fatty acids were detected in inoculated cultivars but not in controls. These acids were extracted from chlamydospores of G. mosseae.

Weather data used to time pecan sprays - Byron, GA. Fungicide applications to pecan trees based on weather data in 1977 and 1978 required fewer applications than the conventional spray schedule but still gave as good control of scab and other foliar and nut diseases. The weather-based sprays were applied after each 125 accumulated hours of leaf wetness while sprays in the conventional schedule are applied at 2 or 3 week intervals. When fully implemented, the weather-based spray schedule could save growers 3 to 6 million dollars a year.

Drip irrigation and soil fumigants increase peach yields - Byron, GA. Supplemental drip irrigation increased peach yields in 1977 (value \$450/acre) more than enough to pay for the system. In 1978, yield increase from irrigation alone were valued at \$628/acre and the interaction of a soil fumigant (DBCP) with irrigation increased yields value by \$1441/acre. Fumigation without water did not affect yields. Post planting fumigation of peach trees has been shown to increase returns per acre by decreasing mortality from peach tree short life but this is the first time in the Southeast that it has been shown to increase production on a per-tree basis.

Rootstock screening technique developed for bacterial canker disease of peach - Byron, GA. A field screening technique was developed to test peach rootstocks for resistance to bacterial canker disease. Rootstock seedlings were artificially inoculated with Pseudomonas syringae bacteria in December and for 2 consecutive years, significant differences were observed. Also, peach trees budded onto the various rootstocks differed in disease susceptibility after natural infection. The disease incidence in naturally infected and artificially inoculated rootstocks was significantly correlated.

Varietal differences observed for peach gummosis disease - Byron, GA. Conidia of Botryosphaeria dothidea induced typical gummosis symptoms when applied to the bark of healthy field grown peach trees. Symptoms appeared 3 to 4 months after inoculations made in June. Potted trees of 20 peach varieties were also artificially inoculated with conidia in the greenhouse. Typical symptoms developed within 5 months and differences in susceptibility were observed among the varieties. The greenhouse inoculation technique may be useful for selecting peach varieties with gummosis disease resistance. Field experiments indicate that Benomyl and Difolatan fungicides will prevent gummosis disease on peach.

Research shows peach tree short life can be reduced - Byron, GA.  
After 5 years, peach trees grown on 2 different short life sites continue to survive when postplant treated with DBCP soil fumigant. Applications of hydrated lime at the rate of 12 lbs per tree site also greatly reduced susceptibility to short life. The continued practices of liming, soil fumigation, and late winter pruning provide commercial growers with the means to prevent severe tree loss if the practices are carried out as recommended.

Phony peach disease variable in orchards - Byron, GA. Enumeration of rickettsia-like bacteria (RLB) in tissues of trees symptomatic for phony peach disease required examination of at least 3 samples due to variability of distribution within the tissues. RLB were more numerous in extracts of root tissues than in terminal twig tissues and more numerous in twigs from current rather than previous year's growth. RLB were also present in symptomless trees in peach orchards with moderate incidence of phony disease but not in an orchard with low incidence. Symptom expression generally followed within 3 to 12 months of first detection of RLB.

Herbicides reduce photosynthesis in apples - Beltsville, MD.  
In research on calcium uptake in apples, all three major herbicides used commercially on apples (terbacil, diuron, simazine) decreased uptake of Ca into apple seedlings at concentrations commonly found in soil solutions. Herbicides decreased photosynthesis which in turn decreased carbohydrate supply to roots and Ca uptake. This may explain why calcium deficient disorders are becoming increasingly prevalent in commercial apple orchards since the common use of herbicides.

New experimental spray system successful in apple orchards - Beltsville, MD. - Fungicide sprays down to 10 liters/hectare successfully controlled scab, powdery mildew, and cedar apple rust on full size apple trees using a modified 3P-50 Pony Kinkelder sprayer during the 1978 growing season. Formulations used in 1978 included Benlate, Captan, and Dodine, as well as Agrimycin and Glyodin. Glyodin was included in all formulations to aid in particle adhesion and slow evaporation of the pesticide while still air-borne. A bioassay inhibition zone technique was used to determine initial and residual concentrations of fungicide applied to the foliage. Using Penicillium variable as the bioassay organism, fungicide concentrations were detected down to 0.5 ppm. Problems remain with the spray delivery system and more work has to be done on this and also with improving pesticide formulations for use with ULV technique before recommending ULV application as a commercial practice.

Four new cooperative apple plantings established - Beltsville, MD.  
A new experiment has been initiated in which a pilot test is designed to gather information on the lowest level of pesticides which can commercially protect apple trees, the productivity of such orchards, the ecosystem of pests after lowering the pesticide level, residue levels on the fruit grown in such orchards, the human exposure to pesticides during hand operation in orchards with lowered pesticide levels, and the economic feasibility of such orchards. Four orchards will be established in this way in Biglerville, PA; Belchertown, MA; Geneva, NY; and Beltsville, MD. Conclusions reached after testing will help to guide the industry in planting new orchards.

Progress made in tissue culture propagation of small fruits - Beltsville, MD. Actively growing shoot tips of the thornless blackberries Smoothstem, Thornfree, Black Satin, Dirksen Thornless, SI-US-68-6-6, and SI-US-68-6-17 were established in culture. Shoots on these cultures are now proliferating and will be rooted to provide the plants for field evaluation. Meristems of the strawberry cultivars Earliglow, Guardian, and Redchief were established in culture from plants which had indexed free of known viruses. Shoots from these meristems were transferred to a proliferation medium and increased to provide the number of shoots needed. This research will greatly help commercial nurseries that are considering tissue culture as a means of rapid propagation of virus-free varieties.

Apple tissue culture research looks promising - Beltsville, MD. New tissue cultures were established from actively growing shoot tips of several apple cultivars and from apical meristems of Golden Delicious. Progress was made on increasing shoot proliferation once the cultures were established without having to resort to using phloroglucinol. Shoots of 8 cultivars have been rooted and plants established in the greenhouse. Success with tissue culture propagation of apple trees would revolutionize the apple nursery industry.

Blueberry nutrition research - Poplarville, MS. Leaf content of N, P, Ca, Mg, Mn, and Fe were highest in plants fertilized with  $(\text{NH}_4)_2\text{SO}_4$  in a sand culture study conducted with 2 year old Tifblue rabbiteye blueberry plants. Nitrogen sources caused no difference in leaf uptake of Al, Zn, B, Cu, and K. Amounts of applied S and Na and leaf content of these elements were positively correlated. Leaf minerals content was not influenced by pH levels from 3.5 to 7.5. Shoot length and number of flower buds were not affected by pH but both were highest for plants fertilized with  $(\text{NH}_4)_2\text{SO}_4$ . Ammonium sulfate was superior to sodium nitrate as a N source, producing higher fruit yield, plant vigor, and leaf macronutrient content.

New pecan planting established in Mississippi - Stoneville, MS. The Stoneville pecan cultivar and selection test plot is well established. Some trees have died and are being replaced. Growth records have been recorded for the first 2 years. The trees have not grown as rapidly as expected because of two extremely cold winters and two dry summers. The 10-acre cooperative study with Mississippi State University and a grower is well established. Data is being collected on cultivar adaptation to this geographic area, methods of orchard establishment, tree spacing, and effect of tree size on orchard establishment.

Fungicides control cranberry fruit rot - Chatsworth, NJ. With research to find effective and economic control measures for cranberry fruit rots, four fungicides (captafol, ferbam, maneb, and chlorothalonil) significantly improved yield and reduced fruit rot as compared to unsprayed checks. Measurement of extracted pigment from the fruit indicated no significant differences among treatments. Control of specific fungal organisms varied with the fungicide tested. Captafol controls Sporonema much better than Physalospora and the reverse was true for ferbam.

Research conducted on cranberry storage - Chatsworth, NJ. Research continues on the effect of berry maturity, bruising, and fresh market shelf-life of water harvested cranberries. Acceleration of berry color by applying ethephon was done to try and get berry color without increasing maturity since maturity decreases keeping quality. The ethephon treated berries did not keep as well as the untreated. Hand picked fruit did not store as well as water picked. This is an indication that bruising may not be as important in storage and decay problems as previously believed. Increasing the time cranberries are left in the water decreased the shelf-life of the fruit.

Minor-use chemicals registered for filberts - Corvallis, OR. Residue analysis on filbert nuts from trees receiving foliar applications of Metasystox-R have been completed. No residues were found. Efforts are underway to have this use registered in the State of Oregon. Registration for the use of glyphosate in bearing filbert orchards was obtained. Work is in progress to develop efficacy data for tank mixes of glyphosate. Norflurazone was registered for use in bearing filbert orchards.

New filbert selections evaluated - Corvallis, OR. A new grower filbert selection Ellis was discovered and evaluated as a pollinizer for the Ennis variety. It was found to be incompatible with Ennis. The cultivar Ennis was topworked on 226 self-rooted rootstock selections and planted with three cooperating growers for subsequent evaluation. This is part of an ongoing program to develop and introduce a filbert rootstock.

ELISA technique used in small fruit research - Corvallis, OR. Enzyme-linked immunosorbent assay (ELISA) is a new, rapid, very sensitive serological technique useful for virus detection. The first ELISA report in the U. S. for plant virus detection was made by this project for tomato ringspot virus in red raspberry in 1978 where one infected dormant plant can be detected among 200 healthy plants by this method. ELISA detection procedures have also been used successfully in this project to detect raspberry bushy dwarf virus in Rubus; tobacco streak virus in raspberry, blackberry, and strawberry; Prunus ringspot virus in Rubus and hops; potato leafroll virus in potato; and tomato ringspot virus in apple.

Spread of cane fruit viruses determined - Corvallis, OR. Tobacco streak virus (TSV) spreads rapidly in the field into normally flowering Munger black raspberry and less rapidly into normally flowering Boysen plants. This suggests pollen transmission mediated by honeybees, from which viruliferous pollen was experimentally obtained. Spread in deflowered plants of both cultivars occurs at a much lower rate indicating a minor alternate method of spread. TSV spreads slowly into flowered but not deflowered Willamette red raspberry. Raspberry bushy dwarf virus spread parallels that of TSV in Munger and Boysen plants but at slower rates and independently of TSV.

Research on strawberry viruses - Corvallis, OR. Research continues on determining which virus strain or strains are responsible for the current strawberry virus disease epidemic in the Pacific Northwest. Mild yellow-edge virus was found to be aphid-spread at random in strawberry fields suggesting the importance of winged aphids in this spread. ELISA tests showed tobacco streak virus to be much less common in the Pacific Northwest than was previously thought. Natural field spread of tomato ringspot virus into strawberry cultivars by dagger nematode has been demonstrated.

Peach trees continue to die in the Southeast - Clemson, SC. Incidence of peach tree short life in Edgefield County, SC was of little importance in tree death during 1978. Recently dead or dying trees were most often infected by Agrobacterium tumefaciens and Clitocybe tabescens. Greenhouse and laboratory tests for pathogenicity of Clitocybe tabescens have failed but new systems are being developed. Agrobacterium tumefaciens isolates from Tennessee and South Carolina are under investigation for control of crown gall in peach nurseries and commercial orchards.

Rootstock and variety improvement research - Weslaco, TX. Redblush grapefruit trees with interstocks again showed smaller canopies. Yield per tree and canopy yield efficiency also improved slightly over the standard sour orange rootstock. Young Nucellar Redblush trees are the largest with citrange and citrumelo rootstocks but are only one-third as big with Old-line Redblush tops. Nucellar Ruby grapefruit trees on 13 rootstocks showed only slight differences in fruit quality and nitrogen in the leaves.

Citrus freeze injury detected by reflectance measurements - Weslaco, TX. Cell membrane injury by freezing was detected in citrus leaves in the near infrared region using reflectance measurements. The injury was detected while the leaf appears water-soaked (an indication of cell sap movement into cellular air spaces) and after the water-soaking was not visible on the upper surface of the leaf. Injury was detected with this technique as early as the first 4 hours after the freezing test, indicating it is possible to detect freezing injury to citrus leaves the morning after a freeze.

New cultural techniques improve hop production - Prosser, WA. A series of spray applications, using paraquat and dinitor, reduced the number of producing hop vines and improved machine pickability. Yield of Tettnanger hops grown on a low trellis, with trickle irrigation, was three times greater than production on a regular trellis. Gibberellic acid applications increased cone number of Bullion hops. Bullion cones pollinated with triploid males were more dense and had more alpha-acids than unfertilized cones.

Stone fruit virus research - Wenatchee, WA. Twenty-two suspected little cherry trees were recently found in the Yakima Valley but little cherry has not spread as rapidly as expected. Why it spreads rapidly in British Columbia and not in the Yakima Valley is not known. One possibility is that the stringent cherry fruit fly spray program has kept the vector controlled. The cherry blossom anomaly incites mild "X-like" symptoms in peach as well as red leaves in chokecherry. Peach leaves express symptoms when inoculated with cherry twisted leaf virus and cherry mottle leaf virus. A limb grooving symptom observed on nectarines was transmitted.

Apple virus research - Wenatchee, WA. With research to detect, isolate, and characterize apple and pear viruses, electron micrographs of isolates from cherry rasp leaf and flat apple disease appear to be identical. Virus-like particles were observed only in dead spur tissue. Tomato ringspot virus was detected in two orchards in Washington and both orchards contained trees expressing symptoms of union necrosis and decline. A bark disorder causing pitting, bark splits, and internal bark necrosis was transmitted to Red Delicious.

Peaches and apples have different fruit set mechanism - Wenatchee, WA. Recent research has shown that chlormequat is an excellent chemical for increasing fruit set of Anjou pears. Ethephon used in past and present trials may be nearly as good but the risk of thinning is an important caution. How chlormequat increases fruit set still is not known. Collected pear fruit samples will be analyzed for zeatin and gibberellins. A good laboratory method for analyzing for cytokinins was developed which will be helpful in learning more about fruit set of pears, apples, and peaches. It was learned that peaches have a different fruit set mechanism than apples.

Experimental chemical partly effective as peach thinner - Wenatchee, WA. Two applications of a new experimental chemical to Improved Elberta peach trees at 44 and 51 days after bloom reduced the amount of hand fruit thinning required by 50%. A single application of the same chemical 44 days after bloom reduced the amount of hand thinning required about 20%. Some phytotoxicity and defoliation occurred, especially with two applications, but the amount of injury was not serious. Fruit size and maturity were unaffected. Research has shown that peaches are much more difficult to chemically thin than apples.

Chemicals reduce fruit rot in storage - Wenatchee, WA. (In cooperation with Oregon State University). Cooperative research continues at Medford and Hood River, OR, on epidemiology of fungus and bacterial diseases of pome fruits. The main work in 1978 was on storage decay. A study of side rot has indicated that some infections may occur in the field before harvest and others in storage after harvest. Post-harvest treatment with sodium o-phenylphenate reduced disease somewhat. Pre-harvest sprays with ziram gave a 50% reduction of disease. Secondary spread of Mucor rot becomes evident after 8 weeks at -1°C. This may have some use in planning the fruit packing strategy. Experimental fungicides have shown promise in controlling blue mold and gray mold rust of pears.

Little cherry virus spreads less in U. S. than in Canada - Wenatchee, WA. Research continues to determine if little cherry virus continues to spread in northern Washington and poses a threat to the cherry growing area in central Washington. Utilizing a combination of visual symptoms and the Acridine Orange fluorescent microscope test, 22 suspected little cherry trees were found. All were in the Yakima Valley. In spot checking the pollenizers which have been topworked in one orchard, it appears that most of the topworked trees in one block are infected with little cherry. Little cherry has not spread as rapidly as expected. Why it spreads rapidly in British Columbia and not in central Washington is not known. One possibility is that stringent cherry fruit fly spray programs have kept the vector controlled. No new findings were detected near Wenatchee or the Canadian border.

Virus and virus-like disease research continues for stone fruits - Wenatchee, WA. Cherry blossom anomaly, a mycoplasma-induced disease, induces color break in velvet and Kansas sweet cherry blooms. It not only incites mild "X-like" symptoms in peach but also causes red colored foliage in chokecherry. Peach leaves were found to express symptoms when the trees were inoculated with cherry twisted leaf virus and cherry mottle leaf virus. In testing cherry trees for little cherry virus, one tree with light colored fruit was found to contain rugose virus. A strain of this virus that causes light colored fruit is known to occur in the lower Yakima Valley but this is the first report in the Wenatchee area. A flat limb condition observed on nectarines has been transmitted. Field spread was observed in research plots for cherry rusty mottle, cherry twisted leaf, prunus ringspot, and X-disease of peach.

Flat apple virus and cherry rasp leaf virus appear to be identical Wenatchee, WA. Tomato ringspot virus was found in two apple orchards in Washington. Both orchards contain trees expressing symptoms of union necrosis and decline. Treatments were applied to the orchard to eliminate the Xiphinema Americanum nematode in an attempt to stop the spread of this disease within the orchard. In a separate study on the relationship between flat apple virus and cherry rasp leaf virus, the isolates from flat apple and cherry rasp leaf virus were purified and examined in the electron microscope. Electron micrographs of the isolates appear to be identical.

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## National Research Program 20020

### BREEDING AND PRODUCTION - VEGETABLES

This National Research Program involves research in breeding and production of vegetables to develop new and improved genetic and cultural methods that will result in lowering costs of vegetables and potatoes to consumers and increasing efficiency of production of these crops to growers, small acreage farmers, and homeowners. Geneticists, plant pathologists, plant physiologists, and horticulturists (both Federal and State) work in a team approach to evaluate and improve vegetables and vegetable cultural methods.

The research is conducted at 17 locations in 14 States in both Federal and State stations where SEA scientists usually work as a team with State scientists.

In 1978 vegetables and potatoes (including dry beans and peas) were harvested from 5.9 M acres with an aggregate value of over \$5 billion.

NPS Contact: R. E. Coleman

#### Technological Objective 1.

New and improved genetic populations, breeding lines, and varieties of vegetables that combine improved yield potentials and favored quality characters, including reduced contents of undesirable constituents, with better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, harvesting, and handling.

#### Research Locations:

3611 Palmer, Alaska  
5213 Brawley, California  
5205 Salinas, California  
7702 Tifton, Georgia  
1313 Orono, Maine  
1108 Beltsville, Maryland  
1110 Beltsville, Maryland  
3508 East Lansing, Michigan  
5809 Corvallis, Oregon  
7617 Mayaguez, Puerto Rico  
7711 Charleston, South Carolina  
7202 Weslaco, Texas  
5806 Prosser, Washington  
5802 Pullman, Washington  
3507 Madison, Wisconsin

## Selected Examples of Recent Progress:

### Carrots:

Improved flavor for carrots - Madison, WI. A new rapid and precise method for determining volatile constituents in small samples of carrot roots provides an objective means of selecting for flavor. After sampling and analyses, the remnant root can be planted for breeding and objective evaluation of progenies for horticultural characteristics.

### Cole Crops:

Progress made toward development of a new male-sterile system for cole crops - Beltsville, MD. Seed fertility was recovered when radish-cytoplasm was substituted into male-sterile broccoli. In the sixth back-cross for transferring the Brassica oleracea genome into an alien cytoplasm (radish), seed fertility was finally recovered, thus permitting a rapid increase of the material for use as a potential source of male-sterile inbreds for seed production of hybrid broccoli, cabbage, and other cole crops.

### Cucumbers:

Bacterial wilt resistance in cucumbers - Madison, WI. Hermaphrodite cucumber lines with bacterial wilt resistance (a combination not previously achieved because of a tight linkage with femaleness) permits the use of such lines as pollen parents in hybrid production.

### Edible Legumes:

Green-seeded Fordhook lima beans resistant to all known races of mildew - Beltsville, MD. Green-seeded Fordhook lima beans developed at Beltsville Agricultural Research Center are now grown commercially for processing in New Jersey. They appear more desirable for home gardens and fresh market than the popular white-seeded cultivar. Downy mildew is the most serious disease of lima beans in the mid-Atlantic States. Control by fungicide applications is costly, time-consuming, and hazardous.

Snap bean cultivars resistant to air pollutants - Beltsville, MD. Most cultivars of snap beans currently available in the United States have been evaluated for resistance to oxidant (ozone) air pollution in field plots at Beltsville and Salisbury, Maryland, in one or more of the past 8 years. Of 387 cultivars and breeding lines tested, 270 were classified resistant; 86 intermediate; and 31 susceptible. Since so many cultivars are resistant, breeding for resistance appears unnecessary.

Snap bean cultivars screened for resistance to Peanut Stunt Virus - Beltsville, MD. Peanut stunt continues to be a damaging disease of beans and other legumes in the middle Atlantic and Southeastern States. The preferred means of control would be through use of resistant varieties, but none had been identified. In efforts to locate resistance, some 214 cultivars have been screened in greenhouse tests. Results show 21 cultivars to be resistant; 88 moderately resistant; 57 susceptible, and 48 very susceptible.

Sources of systemic necrosis in black beans identified - Mayaguez, PR. High levels of resistance to systemic necrosis (BCMV) have been found in P. vulgaris and P. coccineus. This seems to be a new type of resistance which will prevent severe loss of stand to this disease in areas of high incidence such as commercial black beans in the tropics.

Root-knot resistant snap bean reduces nematode population - Charleston, SC. Snap bean lines with genetic resistance to root-knot nematodes grown in infested soil were equivalent to susceptible lines grown in fumigated soil. In addition, a 10-fold reduction in the nematode population resulted from the growth of resistant beans. This type of resistance would have a dual effect on nematode problems. First, the resistant beans would be undamaged, and, second, the following crop could be susceptible, yet productive, due to a low nematode population in the soil.

Resistance in dry beans to seedcorn maggot and seedling diseases - Prosser, WA. Among 60 dry bean breeding lines and cultivars exposed to a severe infestation of seedcorn maggots, two Pink beans, the cv. Viva and a breeding line derived from Viva, showed a very effective level of resistance to this important insect. In field and greenhouse tests, Viva has also proved to be resistant to Pythium and Fusarium seedling diseases. These combined resistances may eliminate the need for chemical seed treatments in these beans.

New, early-maturing, short-vine, multiple-disease resistant bean cultivars - Prosser, WA. Two Pinto beans, two Red Mexican beans, and a Pea (Navy) bean, all with innovative combinations of resistance to the important viruses and (except for the Pea bean) resistance to Fusarium root rot, are in process of release. The new beans combine for the first time the above disease resistances in short, early-maturing, high-yielding plants desired by the industry. The Pea bean will be the first cultivar of its type with a high level of resistance to curly top. These new beans should help stabilize bean yields and permit earlier harvesting of higher-quality beans.

Gene for resistance to pea seedborne mosaic virus transferred to standard pea varieties - Pullman, WA. The pea seedborne mosaic virus resistant varieties will form the major deterrent to the disease which adversely affects yield and seed quality. Resistant varieties represent the most efficient, economical, and reliable method of controlling the disease.

Semi-dwarf, multiple pest resistant pea variety developed - Pullman, WA. WA510104 was developed for its earliness, semi-dwarf determinant growth habit and resistance to Fusarium wilt and its tolerance to pea root rot. WA510104 matures about a week earlier than Garfield and has excellent seed uniformity and quality.

WH 2040 released as the first winterhardy lentil germplasm - Pullman, WA. This winterhardy germplasm, characterized by good seed quality and high potential seed yield, will be a valuable base for the development of an entirely new system of lentil production. Planting lentils in autumn instead of spring planting provides a longer development period and a heat and drouth escape mechanism by earlier blossoming and maturity.

### Melons:

New cantaloup variety released - Charleston, SC. A new cantaloup variety named Mainstream was released for use in the Southern Region. Mainstream produced an average of 26,000 kg/ha from 10 locations in the 1978 Southern Cooperative Trials, compared to 14,800 kg/ha for the control variety, Planters Jumbo. Mainstream is highly resistant to powdery mildew, downy mildew, and cucumber beetles. It also has tolerance to Alternaria leaf blight and melon aphids. Mainstream should be valuable to both commercial growers and home gardeners as a high-yielding, multiple pest-resistant cultivar.

Reducing fungicide applications to control Alternaria leaf-blight - Weslaco, TX. Fungicide application schedules to control Alternaria leaf-blight of cantaloups are usually begun at the first-bloom stage in the crop's development. It was found that by monitoring weather conditions, especially dew periods, to determine the best time to initiate fungicide applications to control this disease, the number of applications could be reduced by one-third without any significant reduction in control efficiency as measured by fruit quality and yield. Basing application schedules on weather conditions will enable growers to reduce fungicide use and lessen crop production costs, while still obtaining effective disease control.

### Onions:

New long-dormant hybrid onions - Madison, WI. Long-dormant hybrid onions, Spartan Sleeper, and others derived from USDA-SEA material, have gained acceptance for home garden as well as commercial production. These are offered in seed catalogs and are widely recommended. With these hybrids, the shipping season can be extended into spring and early summer.

### Potatoes:

New potato varieties in big demand - Presque Isle, ME. The high solids, high quality, widely adapted variety Atlantic released in 1977 continues to increase in popularity. Seed demand far exceeds the supply. Because of Atlantic's high solids content and increased processed product recovery from the raw product over other varieties, processors pay growers a premium of 25 to 50 cents per hundredweight for the Atlantic variety.

Belrus, a medium late maturing, smooth, very high quality russet, resistant to major potato viruses, including tuber net necrosis caused by the potato leaf roll virus, is in major demand in the Northeastern and Midwestern United States. Belrus is expected to complement the Russet Burbank variety in production east of the Rocky Mountains as a fresh market and processing variety.

New potato varieties well adapted to eastern seaboard - Beltsville, MD. Cooperative with Florida, Virginia, New Jersey, and Maine, Belchip, a round, white, widely adapted clone with exceptional processing qualities and well received on the fresh market, immune to viruses A and X and tuber necrosis caused by the leaf roll virus, highly resistant to Race A of the golden nematode and tuber heat necrosis, and tolerant to scab, Rhizoctonia and Fusarium tuber rot, was released to foundation seed producers following 3 years of widespread commercial grower trials.

Belrus, a medium late russet clone with long, smooth tubers, immune to virus A and tuber net necrosis, resistant to Fusarium tuber rot, tolerant to scab, and of exceptional baking and processing quality, was released cooperatively with Maine and Florida following extensive commercial grower, processor, and fresh market trials. Preliminary grower trials indicate Belrus is also adapted to the Midwestern United States.

Resistance to Colorado potato beetle identified - Beltsville, MD. Certain glykoalkaloids found in leaves, but not in tubers of resistant clones of a wild potato species, act as potent feeding deterrents for this insect pest. The resistance-susceptibility of clones in a segregating family of wild potatoes was related to the presence of certain types of glycoalkaloids in the leaves. The findings show that it may be possible to transfer the genes for the production of the particular glycoalkaloids that deter beetle feeding from leaves of resistant wild plants to leaves of cultivars without affecting the chemical composition of the tubers.

High-quality, multiple-pest-resistant potatoes - Prosser, WA. New potato clones have been developed which combined resistance to verticillium wilt, sclerotinia wilt, early blight, and powdery mildew. In addition, some of them also have resistance to leafroll, net necrosis, common scab, deep-pitted scab, Colorado potato beetle, hollow heart, knobs, growth cracking, and Sencor herbicide, all of which cause serious problems in current commercial varieties. This resistance could be worth millions each year to Northwest growers, packers, and processors. The disease and pest resistance could be an extremely valuable part of any integrated pest management program.

Confirmation of the Endosperm Balance Number (EBN) theory in potato - Madison, WI. The Endosperm Balance Number (EBN) proposal of Johnston, den Nijs and Peloquin has been tested and seems to explain most endosperm failure in interploidy crosses in the tuber-bearing Solanums (potatoes). The EBN proposal is that the successful development of the endosperm is minimally dependent on a two maternal EBN to one paternal EBN ratio in the endosperm itself and is independent of the ploidy level of the species. The EBN is assigned empirically on the basis of cross compatibility. Most diploid species have 2 EBN, but some may have 1; most tetraploids have 4 EBN, but some have 2 EBN, and all hexaploids have 4 EBN. This proposal has value in predicting the success or failure of interspecific crosses and the ploidy of the offspring. It may be of value in determining evolutionary relationships among species. It appears to be applicable to other genera and may have a broad biological basis.

Long-term preservation of tuber-bearing Solanum species is a possibility - Madison, WI. Shoot tips and pollen of several Solanum species survived treatment to liquid nitrogen temperatures. This means that long term storage for IR-1 Potato Introduction Project germplasm is possible and can, thus provide a reservoir of stocks should an original line be lost or altered through normal maintenance procedures. Virus-free materials stored in the form of nodal cultures at refrigerator temperatures provide

a low maintenance procedure for keeping a nuclear stock of the free material in case the original line becomes reinfected during normal propagation procedures.

#### Sweet Corn:

Cause of low seed vigor in high-sugar sweet corn identified - Charleston, SC. Tests were made to determine the causes of low seed and seedling vigor in sweet corn lines with the high-sugar genotypes compared to normal. Reduced vigor was associated with smaller and less supportive endosperms. While embryo genotype played an important role in seedling vigor, differences observed could not be attributed wholly to genetic inferiority of the embryo from high-sugar lines. Improving seed and seedling vigor in the high quality sweet corn would greatly enhance its usefulness to the sweet corn industry and help to bring a better quality product to the consumer.

#### Tomatoes:

Release of two tomato varieties for processing - Beltsville, MD. Two tomato varieties were released to tomato seed producers under the names US28 and US141. During 2 years of extensive testing in experiment station, processing and seed company, and grower trials, both lines have shown wide adaptability, good yielding ability, excellent firmness for mechanical harvesting and bulk handling and good fruit quality for canning whole or product manufacture. These combinations of traits make the lines useful to the tomato canning industry in the Eastern and Mid-western U.S. Commercial production of US28 and US141 will be limited to several hundred acres in 1979 because of seed supplies.

Curly top resistant tomatoes - Prosser, WA. A level of curly top resistance has finally been developed in tomatoes that is comparable to that found in resistant sugarbeets. The development of resistance in tomatoes has required painstaking and intensive effort over a 48-year period and was not thought possible by most tomato breeders. This resistance makes tomato production possible throughout the Intermountain West well adapted to tomato production except for the curly top disease. It can also reduce the risk of losses in the important production area of California.

#### Technological Objective 2.

New and improved cultural and management practices that increase vegetable yields, minimize production losses, improve quality attributes, and conserve and use scarce resources efficiently.

#### Research Locations:

3611	Palmer, Alaska	1108	Beltsville, Maryland
5213	Brawley, California	3508	East Lansing, Michigan
5205	Salinas, California	5809	Corvallis, Oregon
7702	Tifton, Georgia	5806	Prosser, Washington
1313	Orono, Maine		

Artichokes:

Use of offshoots for planting artichoke fields - Salinas, CA. Use of offshoots for planting artichoke fields was shown to be superior to the conventional method of crown plantings for producing an earlier crop and concentrating total yield into shorter time period. Higher yields were obtained when offshoots were planted 1 foot apart within rows. These improved cultural practices could result in a lower cost of artichokes at the retail level since the crop is not in the field as long and because less labor is needed for harvest compared to conventional practices.

Monitoring of plume moth egg counts offers more effective insect control for artichokes - Salinas, CA. Monitoring of plume moth egg counts on a weekly basis resulted in more timely and effective application of insecticides to control this serious insect pest of the artichoke. To the consumer this could result in a lower cost of artichokes at the retail level. To the apiarist it means that, due to properly timed applications of insecticides, he could expect reduced loss of pollinating bee colonies which are often stored in artichoke production areas.

Edible Legumes:

New diagnostic key for legume viruses - Corvallis, OR. A definitive diagnostic key for the identification of viruses infectious to northern temperate-climate legumes by symptomatology on sap-inoculated herbaceous indicator plants was published by an international team of plant virologists headed by Dr. R. O. Hampton.

Ontario Irish potato cultivar highly resistant to bacterial wilt - Tifton, GA. 'Ontario' was the only potato cultivar found to be highly resistant to bacterial wilt (1% level), a soilborne disease caused by Pseudomonas solanacearum in mild temperate and tropical regions of the world. The 32 cultivars were grown in soil with a high level of this bacteria and also every plant was artificially inoculated. 'Ontario' may have potential in underdeveloped countries and in breeding programs for warm regions.

VARIETIES RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
Bean, Pole 'Footlong'	SC AES and SEA	Rhizoctonia resistance
Cantaloup 'Mainstream'	SEA	Flavor; vitamin C; small size
Cucumber 'County Fair'	SEA and WI AES	Seedless; home garden
Lentil 'Red Chief'	SEA and WA AES	High yield
Potato 'Delta Gold'	SEA and ME AES	High solids; yellow flesh
Potato 'Belchip'	SEA and FL, VA, NJ, and ME AES	Disease resistant; processing
Potato 'Denali'	SEA and AK AES	High solids; processing
Tomato 'US28' & 'US 141'	SEA	VF processing type
NONCOMMERCIAL GERMPLASM		
Bean, Lima Breeding Lines F-372 F-1072	SEA	Downy mildew resistance
Bean, Snap Breeding Lines ARS-6BP-5 ARS-6BP-6 ARS-5BP-7	WA AES and SEA	Curly top and common bean mosaic virus resistance;
Cucumber Breeding Lines W 744 GP W 1082 HP	SEA and WI AES	Seedless; multiple disease resistance
Lentil Germplasm Line ARS-WH 2040	SEA and WA AES	Cold tolerant
Pea Breeding Lines VR 74-410-2 VR 74-1492-1  ARS-244219-B	SEA and WA AES	Resistant to seedborne mosaic and wilt " " "  Edible pod

## SELECTED PUBLICATIONS

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## National Research Program 20030

### BREEDING AND PRODUCTION - FLORIST AND NURSERY CROPS

This National Research Program deals with multidisciplinary research to develop new technology for improving productivity and increasing efficiency in the production of florist and nursery crops to enhance urban and rural environments. This need for new knowledge makes it essential to provide research results on selecting, improving, protecting, maintaining, and cultivating plants for urban and rural home, landscape, and special purpose plantings such as parks, road-side, and shopping centers.

Florist and nursery crops fulfill a social as well as an agricultural need. They affect human feelings and attitudes and greatly enhance human surroundings. Green plants and flowering plants are being used increasingly in and around homes, offices, and public buildings. The retail value of foliage and pot plants is estimated at over \$1 billion annually. The growth in the bedding plant industry in the last few years is probably unexcelled by any other agricultural commodity.

The USDA research program in Florist and Nursery Crop Production Practices is located at three primary centers: Washington, D.C.-Beltsville, Maryland; Delaware, Ohio; and Corvallis, Oregon. These programs are located at Federal and State research stations where SEA scientists work closely with State scientists and closely complement research activities in State programs.

NPS Contact: R. E. Coleman

#### Technological Objective 1.

New and improved genetic populations, breeding lines, and varieties of florist and nursery crops that combine improved and favored quality characters, with better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, harvesting, and handling.

#### Research Locations:

1211 Washington, D. C.  
1108 Beltsville, Maryland  
3605 Mandan, North Dakota  
3306 Delaware, Ohio

#### Selected Examples of Recent Progress:

New camellia hybrids developed - National Arboretum, Washington, D. C.

Two new Camellia hybrids, Camellia 'Ack-Scent' (C. hybrid 'Fragrant Pink Improved') ■ fragrant-flowered cultivar of commercial size and quality, and Camellia 'Frost Prince' (C. hiemalis x C. oleifera) ■ cold-hardy

cultivar with plant characters resembling the hardy parent C. oleifera, and flowers comparable to commercial cultivars of C. hiemalis have been released and registered.

New holly hybrids released - National Arboretum, Washington, DC. A female ('Sparkleberry') and a male ('Apollo') cultivar resulting from hybridization between Ilex serrata and I. verticillata are now available from commercial nurseries. 'Sparkleberry' is a large, deciduous upright shrub with outstanding fruiting and landscape characteristics. 'Apollo' will serve as a reliable pollinator. Two new evergreen holly hybrids have also been released. 'September Gem' is a seedling selection of the cross I. ciliospinosa x (aquifolium x pernyi) with a pyramided habit and large, red fruit. 'Clusterberry' is a seedling selection of the cross (I. cornata x aquifolium) x leucoclada and produces glossy red fruit in dense clusters. These new cultivars are superior to others of their type for landscape and home planting.

New disease resistant pyracanthas - National Arboretum, Washington, DC. Multiple disease resistance to scab and fire blight has been achieved with the introduction of two pyracantha cultivars, 'Navaho' and 'Teton.' 'Navaho' is a low, densely branching, semi-evergreen plant with narrow, dark green leaves. The luminescent orange-red fruit ripens in November and remains on the plant throughout most of the winter. 'Teton' has a very distinct, upright growth habit, and medium green foliage. The light yellow fruit ripens in October and matures to a medium yellow-orange, which persists on the plant until January. 'Navaho,' which is dwarf, and 'Teton,' which is distinctly upright, provide new growth habits combined with disease resistance for landscape use.

Wilt resistant mimosa - Tifton, GA. After many years of testing and selection, a Fusarium wilt-resistant mimosa (Albizia julibrissin) has been released and will be distributed in the fall of 1979. The tree has proven cold-hardy at the U.S. National Arboretum, Washington, DC, since 1970. The cultivar, named 'Union,' was first transplanted into an area naturally and heavily infested with the mimosa wilt organism at Union, SC, in 1953. Subsequent testing and propagation has been cooperative with the Georgia Coastal Plain Experiment Station.

Seed collection guidelines for red maple - Delaware, OH. Broad seed collection guidelines have been developed for nurserymen to collect genetically superior red maple seed for lining out. These initial guidelines have been developed from genetic testing of native seed sources of red maple. Nurserymen can get better growth rate, fall color, symmetrical form and vigor in their seedling stock by using these guidelines. Consumers of seedling red maples will be able to purchase better quality trees.

Exotic tree species found highly tolerant to deicing salt - Delaware, OH. Japanese Scholar tree (Sophora japonica) was found highly tolerant to deicing salts. This urban tree species showed the least foliar injury of seven species screened for tolerance to deicing salts. Cities and towns can use this species where deicing salts injure most other deciduous tree species.

## Technological Objective 2.

New and improved cultural and management practices that increase florist and nursery crops yield, minimize production losses, improve quality attributes, and conserve and use scarce resources efficiently.

### Research Locations:

7702 Tifton, Georgia  
1108 Beltsville, Maryland  
3306 Delaware, Ohio  
5809 Corvallis, Oregon  
5804 Puyallup, Washington

Fingerprinting of plants, breeding lines, and clones - Beltsville, MD. Sampling techniques and procedures for resolving and quantifying the anthocyanins in poinsettias were developed. Twenty-seven poinsettia cultivars were analyzed and were distinguished from each other on the basis of the anthocyanin constitution. Results indicate the feasibility of using anthocyanins as chemical markers and as an adjunct to existing subjective methods for identifying cultivars protected by the plant patent law and variety protection act.

Supplemental lighting in greenhouses - Beltsville, MD. High pressure (HPS) and low pressure (LPS) sodium lamps (at 22 W/m<sup>2</sup> from 0800 to 2400 hrs.) were equally effective in promoting rapid growth and early flowering of foliage and flowering plants. When the intensities were reduced from 22 to 11 to 5.5 (W/m<sup>2</sup>) from 0800 to 2400 hrs.) HPS was more effective than LPS in promoting rapid growth and flowering of such plants as corn, gloxinia, petunia, snapdragon, soybean, and strawberry. HPS and LPS were equally effective (at 5.5, 11, and 22 W/m<sup>2</sup> 0800-2400 hrs.) in promoting rapid growth and early flowering of begonia, browallia, catalpa, chlorophytum, geranium, lettuce, pilea, and rose. Findings suggest that plants can be classified into energy-requiring types based on their sensitivity to visible, ultraviolet, and infrared.

Tree injection system perfected - Delaware, OH. A portable, air-powered injection system was developed and field-tested for introducing aqueous chemicals into trees efficiently and economically. The equipment has wide-spread applicability for use in growth control, insect and disease control, and as a means of providing supplemental tree nutrition.

Aqueous formulations of maleic hydrazide and dikegulac were tested extensively as growth control chemicals in a variety of tree species growing in a range of geographic areas. These materials proved effective in controlling sprout regrowth for most species up to 2 years from a single treatment.

Tolerant fungus strains of Dutch elm disease identified - Delaware, OH. Dutch elm disease fungus strains were found that are not inhibited by relatively high concentrations of benzimidazoles, the fungicides recommended to control the disease. We have shown that the disease is not

controlled by benzimidazoles when a tolerant strain infects an American elm. The tolerant strain is stable and does not revert to the sensitive form for at least 3 years, and it is as pathogenic as the sensitive strain. If tolerant strains become widespread in the fungus population, it is possible that benzimidazoles will no longer be useful in disease control.

Fungicide volatilization controls greenhouse disease - Corvallis, OR. Powdery mildew is the most costly and troublesome disease of cut rose production and is presently only partially controlled by repeated and consistent fungicidal sprays. The discovery of the total protection and even eradication of the disease in a commercial greenhouse by volatilizing fungicides applied to a hot pan or heating pipes offers real hope for control in the future. This system has been effective with materials applied in small amounts in a greenhouse closed up for 4-6 hours during the night, making application safe, economical, and remarkably less polluting, yet giving complete coverage and control. The volatilization principle has application to many other greenhouse foliage disease situations.

Weevil feeding preference in rhododendron - Puyallup, WA. The problem of weevil feeding damage on rhododendrons is of major significance to the nursery industry, but also to the multitude of home gardeners that experience great loss due to these pests. Weevils feed on certain Rhododendron species and not on others. For example, R. thompsonii is susceptible while R. williamsianum is resistant to weevil feeding. Results have indicated some morphological differences but also that susceptible species form extractable attractants (of which sucrose is one) which if added to resistant leaves or cellulose acetate filter discs, makes them palatable to feeding weevils. Resistant species have extractable inhibitors. This knowledge is important in developing modified pest control strategies which might be good alternatives to pesticides as well as selection for resistant hybrids.

Accumulated photosynthate does not suppress photosynthetic rate - Corvallis, OR. The possible inhibition of photosynthesis by its products is a long standing question of importance especially to breeders selecting for high photosynthetic rates of crop plants if photosynthesis were self-limiting by its products. Plants forced to accumulate starch up to 50% of the leaf dry weight under continuous light did not show a significant decline in photosynthetic rate indicating the lack of a feed back mechanism.

### Technological Objective 3.

To enhance environmental quality by reducing pollution and improving man's surroundings.

### Research Locations:

1108 Beltsville, Maryland  
3306 Delaware, Ohio  
5809 Corvallis, Oregon

Selected Examples of Recent Progress:

UV-B, ultraviolet enhancement--impact on landscape plants - Beltsville, MD. Seventy-four florist and nursery crops were irradiated with a range of ultraviolet (UV) from 50 to 400% increase in biologically effective UV. Visible injury was noted in only 8 of 74 species. None of the 21 shrub or tree species showed any sign of stress response under 12 weeks of UV-B. Aster, browallia, coleus, fatsia, hollyhock, impatiens, poinsettia, and vinca plants irradiated for 4 weeks developed slight chlorosis (degradation of chlorophyll). Results suggest that enhancement of ultraviolet due to the loss of ozone screen in space will have little detectable effect on growth of most landscape plants.

Ethylene and plant stress - Corvallis, OR. Ethylene is evolved by plants subjected to environmental stresses including air pollution and fungal pathogens, often before visible signs of the disease, other stress damage, or a growth reduction. In the case of disease, ethylene is evolved within hours after penetration of the fungal pathogen. The pathogen, Cylindrocladium, is able to produce ethylene in vitro only in the presence of methionine, a normal constituent of plant tissue. Apparently a light sensitive precursor is involved, suggesting a microbial ethylene synthesis pathway never before described.

VARIETIES RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
Cenquefoil 'Dakota Sunrise'	SEA	Drought resistance
Crape Myrtle 'Muskogee'	U.S. National Arboretum	Disease resistance
'Natchez'		
'Tuscarora'		
Mimosa 'Union'	SEA & GA AES	Wilt resistant
Green Ash 'Cardan'	SEA & SCS	Conservation and amenity
Poinsettia 'Winter Sunshine'	SEA	White cultivar
Viburnum 'Shasta'	U. S. National Arboretum	Superior landscape plant
Pyracantha 'Navaho'	U.S. National Arboretum	Fire blight tolerant
'Teton'		

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National Research Program 20040

BREEDING AND PRODUCTION - CORN, SORGHUM and MILLETS

This program is part of the USDA-SEA-AR Mission 2 - Agricultural Production Efficiency with the goal of producing new knowledge and improved germplasm to increase grain productivity. These important feed grains (see NRP 20100 for forage aspects of these commodities) are of major significance for both domestic and export utilization as food, feed and industrial use. To a lesser degree the program contributes to Mission 3 - Agricultural Marketing and Distribution and Mission 10 - Foreign Agricultural Development. The program is organized under two technological objectives.

NPS Contact: P. H. Harvey

Technological Objective 1.

New and improved genetic populations, breeding lines, and hybrids of corn, sorghum and millets that combine improved yield potentials and favored quality characters, including reduced contents of undesirable constituents, with better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, harvesting, and handling. Develop basic genetic, cytogenetic, physiologic, and biochemical knowledge necessary to accomplish these goals.

Research Locations:

7602	Gainesville, Florida
7702	Tifton, Georgia
3420	Manhattan, Kansas
3311	Urbana, Illinois
3302	West Lafayette, Indiana
3408	Ames, Iowa
1108	Beltsville, Maryland
7502	Mississippi State, Mississippi
3402	Columbia, Missouri
3416	Lincoln, Nebraska
7802	Raleigh, North Carolina
3307	Wooster, Ohio
3608	Brookings, South Dakota
7302	College Station, Texas
7617	Mayaguez, Puerto Rico
0203	Kenya, East Africa

Selected Examples of Recent Progress:

Corn:

Host-plant resistance to pests - Tifton, GA, Ames, IA, W. Lafayette, IN, Mississippi State, MS, Columbia, MO, Raleigh, NC, Wooster, OH, College Station, TX, and Kenya, East Africa.

Alfatoxin: Phytotron experiments were initiated on the influence of preinoculation and postinoculation temperatures on aflatoxin in developing corn ears. Ears inoculated with A. flavus about the hard dough stage, and grown at high temperatures (day/night 30/26 C) produced high levels of toxin (34,400 ppb), whereas ears inoculated early and grown at low temperature regimes gave low toxin (1,650 ppb).

Aflatoxin screening and survey work: We continue to accumulate evidence for genetic differences among corns in their ability to resist the development of high levels of aflatoxin contamination. A 45-county survey indicated that the incidence of aflatoxin contamination of field corn samples was nearly the same in 1978 as in 1977, but that the level of contamination was drastically lower in 1978.

Our challenge to produce more food on fewer acres will certainly require more intensive land use. Planting corn on an area immediately after the wheat crop is harvested would be one method of more fully utilizing available land. Although not feasible with currently available commercial corn hybrids, our experimental hybrids which have resistance to fall armyworm and southern rust could, if grown with irrigation, make it feasible.

Tests conducted for 91 S<sub>2</sub> opaque-2 families indicated seedling response was highly heritable for F. moniliforme, G. zeae, and P. ultimum. Genetic correlations for responses to the three fungal pathogens indicated that breeders can restrict themselves to only one pathogen and expect similar response to others.

Released in 1978 inbred B84 was selected for intermediate resistance to first brood European corn borer and high combining ability for yield. The inbred has promise as a parent stock in commercial hybrids. In 3-year trials in Iowa it has outyielded B73 x M017 by 17.9% when combined with M017.

Nine additional sources of resistance to strains A and B, the two widely distributed strains of maize dwarf mosaic virus (MDMV) were found. Some of these should be valuable as breeding lines for transferring resistance to sweet corns which all appear susceptible, and to field corns for growing in the irrigated areas of Kansas and Nebraska where maize chlorotic mottle virus (MCMV) occurs. Combined MDMV and MCMV infections cause a lethal disease in corn.

Two-hundred and fourteen exotic maize cultivars were tested for resistance to sorghum downy mildew. Eight resistant cultivars were identified. F<sub>1</sub> and F<sub>2</sub> progenies of crosses of resistant and susceptible inbred lines were tested for reaction to sorghum downy mildew. Dominance for resistance was intermediate.

Seven individual progenies from a S<sub>1</sub> generation of field selection of previously tested entries continued to demonstrate resistance to SCMV. Presently individuals from S<sub>2</sub> generations of Coast Composite, MAD H302 and Ph:DMR-5 appeared highly resistant and/or tolerant to SCMV by mechanical inoculation. A U.S.-adapted inbred, Pa405, was also found immuned to SCMV.

Pathological research on corn pathogens - W. Lafayette, IN, Columbia, MO, Raleigh, NC, Wooster, OH, and Kenya, East Africa. Over 450 isolates of Cochliobolus carbonum collected from cornfields in North Carolina were analyzed for virulence, mating type, fertility, and sensitivity to cycloheximide and carboxin. Genetic variation within fields was similar to that between fields in the same area. Race 3 of C. carbonum has increased in frequency in areas east of the mountains in recent years. Frequencies of cycloheximide tolerance and ability to form perithecia differed widely between races 2 and 3 in all regions.

Maize rayado fino virus (MRFV), previously unknown in the U.S. was found in Texas and Florida. MRFV may become a problem in the U.S. if it were to adapt to a plant in which it could overwinter in more temperate areas. Especially since the leafhopper Graminella nigrifrons, found to be a vector, occurs abundantly over the eastern U.S.

Comparative tests of the reliability of (ELISA) and infectivity assay (IA) for identifying strain A and B of maize dwarf mosaic virus (MDMV) were made with diseased maize samples. Discrepancies in identities existed between the two test methods in 18 of 70 samples assayed. It was judged that ELISA was more reliable than the IA for correctly identifying these strains, especially for assays of leaf tissue that had been frozen.

The sedimentation rate was determined for a maize infecting isolate of foxtail mosaic virus (FMV) from Louisiana. The value was determined by rate-zonal centrifugation assay in linear-log sucrose gradients with cucumber mosaic and tobacco mosaic viruses as the reference particles. The S<sub>20,w</sub>'s were 127S and 146S for the slow and fast sedimenting bands, respectively. The values match those reported for the type strain of FMV.

Sporulation by Setosphaeria turcica on susceptible corn leaves followed a triangular pattern beginning 17 days after inoculation, peaking at 22 days, and effectively ending at 29 days. Use of these data in the Volterra equation allows prediction of how much the rate of disease increase can be reduced by resistance that extends latent period or reduces sporulation or infection efficiency by known amounts. Similar data were found in the literature to extend this type of analysis to stem and leaf rusts of small grains, rice blast, and downy mildew of cucumbers.

Carbofuran was identified as a fungicide against Diplodia maydis growth in Zea mays L. when artificially inoculated maize plants resistant and susceptible to Diplodia maydis stalk rot were treated with carbofuran. Growth of the fungus was inhibited. This could be significant in the control of this type of stalk rot.

A difference was found in the Erwinia stewartii, Stewart's wilt disease, population in ability to increase or decrease in virulence in resistant and susceptible inbred lines of corn. Of three isolates, one increased in virulence on a resistant inbred and two in a susceptible inbred, and another did not change in either inbred.

A difference in pathogenicity was found among 48 isolates of E. stewartii from Missouri: 36 were weak, 6 moderate, 5 high and 1 very highly pathogenic. From the first finding, however, weakly virulent isolates may increase in virulence throughout the season as they pass through secondary infection cycles on corn during the growing season.

Aspergillus flavus has been found in all corn growing sections of Missouri. Airborne spores are present in all areas throughout the growing season. Of 31 isolates collected by air samplers, 65% produced aflatoxin in corn kernels. A rapid method for detecting aflatoxin-producing isolates was developed. Isolates from corn kernels placed in coconut agar provided a speedy test for identifying those with aflatoxin-producing ability, eliminating the time-consuming chemical analyses.

Studies of the life cycle of Colletotrichum graminicola showed the organism survived in residue on the soil surface, in the kernel of corn and sorghum for more than 12 months. Incorporation of residue in the soil hastened decomposition of residue and reduced the time of survival of C. graminicola. A 2-year study on survival revealed that the organism did not produce Sclerotia under Indiana conditions. However, the fungus survived as a thickened mycelium in the stalk tissue. Fall plowing of fields with infested residue reduced the number of viable propagules and is recommended as a control measure.

Sugarcane mosaic virus (SCMV) and/or maize streak was found in seven of seven Kenyan provinces surveyed. SCMV-infected maize, sorghum, sugarcane, or weed hosts were only found in the Western Plateaus, Kenyan Highlands, and the Rift Valley geographical regions of these provinces.

Yield losses in 10 major Kenyan hybrids to SCMV varied from an average of 17.8% (H614C) to 45.9% (H613C). Yield losses varied according to time of infection and the hybrid involved. Yield reduction for all ten hybrids averaged 29.4, 38.7 and 21.4% when inoculated at 10-15, 30-40, and 122-170 cm tall, respectively. Yield losses in hybrid H512, H632, and H611C, but not EAH 6302 and H614C varied with time of infection.

Developing and evaluating breeding systems - Tifton, GA, Ames, IA,, Raleigh, NC, Wooster, OH, and Kenya, East Africa. Inbred B73 was released in 1972 as a parental seed to commercial seedsmen for use in hybrids. B73 was high combining ability with MO17. Use of B73 x MO17 hybrids is estimated to increase average yields 10%. It is estimated that B73 was used in hybrids grown on 18 to 20 million acres in 1978, with the main concentration being in the irrigated areas of the Great Plains and the central Corn Belt. Reports also indicate B73 x MO17 is an outstanding hybrid in southern Spain, northern Italy, and in China.

Lines extracted from the recurrent selection programs are used in commercial hybrids. Survey for 1976 seed requirements showed that 33% of hybrid seed produced on lines that had Iowa Stiff Stalk Synthetic germplasm. Since 1972, B73, B77, B79, and B84 have been released to commercial seedsmen.

Two improved strains of corn designated NC IR10 and NC JR10 were released in 1978 for use by corn breeders. These elite strains were developed cooperatively by the North Carolina Experiment Station and the U.S.D.A. from a reciprocal recurrent selection program initiated more than 20 years ago. The strains should be very useful as sources of germplasm and inbred lines for developing better hybrids for the Southeast.

Long-term recurrent selection programs are being conducted in 16 populations of normal corn and in two populations for improved yield and protein content and quality. These selection programs play an important role in the improvement of breeding populations and extraction of lines from the improved breeding populations. Thirty-four (34) populations have been released for use in commercial breeding programs. The impact of the breeding populations on commercial breeding programs is not known, but the requests for seed allotments indicate commercial breeders are aware of their possible potential for line development. Average grain yield response from recurrent selection was about 3% per cycle.

A statistical model evaluating progress from recurrent selection indicated significant changes in the weighted average change in allelic frequency and the amount of inbreeding depression in these populations.

An extensive study evaluating five different testers showed that the component of variance among testcrosses was greatest at the S<sub>1</sub> and S<sub>8</sub> level for elite unrelated line (MO17) and low yielding related line; for applied breeding programs, the choice of unrelated tester would be the proper choice. Relation between line per se performance and testcross performance was not predictable.

Simultaneous selection for several characters within three different populations resulted in improved yield and husk tightness in two of the three populations. Progress for other characters is not definitive at this time. Initial improvement of populations having poor agronomic characteristics can be made using simultaneous mass selection of these traits.

Evaluations of the original population with populations selected on the basis of various selection indexes indicated that the greatest progress in reducing corn earworm injury resulted in those populations for which husk tightness was also increased. Husk extension and yield generally showed negative responses when corn earworm resistance improved. More emphasis must be placed on husk tightness per se if progress in ear-feeding resistance is to be made.

The review of the Kenya maize research program involved processing data from 1977 which had not been done due to Darrah's departure in mid-1977 without replacement. Evaluation of  $S_3 \times S_3$  crosses of Kitale II and Ecuador 573 lines showed Ecuador 573(R12) C4-82 to be a line with tremendous potential for use in three-way crosses with existing female single crosses. Other data from the 1976-77 regional maize trial and the 3-year evaluation of breeding methods were brought back to the U.S. for writeup. Personnel losses resulted in less program direction than in the past and this review pulled together the national maize research team establishing a better relationship between persons in charge of breeding and agronomy and their field staff.

Reduction of genetic vulnerability - Tifton, GA, Ames, IA, Mississippi State, MS, Columbia, MO, Raleigh, NC, and College Station, TX. The computerized system for cataloging, updating, and retrieving data collected from the extensive exotic germplasm evaluations (work cooperative at five locations) has been completed and tested. One-hundred and sixty-two racial collections not previously evaluated were tested for numerous pest reactions and agronomic traits.

Twelve high-yielding racial collections were chosen as parents for two six-race diallel studies. Diallel analyses of data collected at three locations showed that variation due to general combining ability predominated. Six of these racial collections have been chosen for use in population improvement programs.

Two populations selected in Mexico for stalk strength were grown in separate isolations for random mating and mass selection for maturity and desired agronomic type. Lines from four exotic base populations were grown in a disease nursery in cooperation with a commercial company and selected for virus and leaf diseases. Progeny from 17 CIMMYT base populations which had been outcrossed to northern corn belt material were tested by growing approximately 45  $S_1$  lines of each. Selections were made by saving 63% of the lines according to desirability for ear height, lodging resistance, smut resistance and overall agronomic potential.

Biochemical aspects of grain quality - Urbana, IL, Ames, IA, Manhattan, KS, and Beltsville, MD. No phenotypic criteria are available for accurately assessing protein and amino acid levels. While opaque-2 can be visually identified, chemical analyses are needed for accurate estimates. Approximately 700 samples involving the opaque-2 gene in segregating population and 1900 samples of normal corn were analyzed in the total program. The opaque-2 gene increases lysine content almost double that of normal corn. However, when it is placed in a genetic background of agronomically desirable characteristics the percentage is reduced. Modified types or strains are being evaluated and recombined to develop germplasm with both good yield and higher lysine levels. Good recurrent selection lines now have about .45% lysine. Commercial corns have about .25% lysine in the samples and pure opaque-2 lines about .55%.

No specific gene(s) is known that influences protein as in the case of lysine. Considerable variation exists; however, and chemical analyses are made on recurrent selection populations to identify strains with accumulated genetic factor for increased protein that also have the opaque-2 gene for lysine. Protein can and has been increased in corn. The classical "high protein corns" are not well adapted and yield poorly. Our effort is directed toward isolating well adapted germplasm with the highest protein level practical. Lines with high levels are recombined to maintain or increase protein percent. A range of 6 to 13% protein has been observed in our analyses. The 13% represents a 30% increase over the commonly accepted value of 10% for older standard varieties. Modern hybrids average less than 10%.

Evaluation trials conducted under cold soil conditions (planted early April) indicate emergence traits are heritable and that the single mutant opaque-2, has better germination and emergence than the double mutant, sugary-2, opaque-2.

The soluble proteins of the endosperm produce a basic pattern of eight bands, which differ in intensity among inbreds. One band was identified as sucrose synthase. Opaque-2 inbreds usually lack one or two bands, but no common marker pattern was seen for this mutation. One major band was reduced in all flowery-2 inbreds.

Free fatty acids (FFA), lysophospholipids and lysoglycolipids were the most difficult lipids to extract and appear to be tightly bound in the starchy endosperm. These compounds were found almost exclusively in the endosperm. Only trace amounts were observed in germ. Corn endosperm appears to contain a much higher level of FFA than other cereal grains. The FFA may affect the properties and keeping quality of fractions milled from corn endosperm.

Quantitative genetic research - Ames, IA, and Raleigh, NC. A model which related changes in the mean of improved populations to changes in allelic frequencies, types of gene action, and inbreeding depression was developed and evaluated using data from previous studies conducted to evaluate progress achieved by recurrent selection. The results indicated that

progress was due to increasing alleles with additive effects. Significant inbreeding depression was indicated and the associated genetic drift may partly explain why actual gains have been less than predicted gains.

Emphasis is being given to improvement of agronomic traits and improved protein content and quality in two broad-gene base populations. Studies indicate progress can be made for seedling emergence and vigor, kernel hardness, and disease resistance. Relations among three seedling fungal pathogens indicated breeders could restrict themselves to one pathogen and effectively select for resistance for all three pathogens.

Cytogenetic and genetic investigations - Columbia, MO. Through the use of genetic marking and x-ray induced mutations (in collaboration with M. G. Neuffer of the University of Missouri), the embryo of the corn seed at planting has been discovered to be compartmented in the destinies of the cells of the embryo, with 2-4 cells destined to become the tassel, 16 cells the upper several leaves, 32 the top two or three ear nodes (including 2-4 cells for each ear), 32 the two or three nodes below, 32 the next lower two or three nodes, plus the 5-6 preformed leaves at the base of the plant. The remarkable growth rate of the corn plant is thus achieved by compartmented growth assignments of the cells of the embryo; this knowledge of the developmental mechanics provides a foundation for devising optimum time strategies in cultural practices, as well as for basic understanding of the process of development.

The light-capturing structure of the cell, the chloroplast, although carrying its own DNA, is greatly dependent also on genetic formation of the nucleus. The nuclear gene *iojap* has been shown, by biochemical studies and electron microscopy (in collaboration with Dr. Virginia Walbot of Washington University), to result in chloroplasts that are permanently unable to make proteins, to become green or to function in photosynthesis. Clonal developmental analysis shows that the chloroplasts undergo changes at "programmed" stages during plant development, affecting their functional competence in specific parts (i.e., compartments) of the plant; this knowledge increases our understanding of the mechanisms by which specialization of different plant parts occurs in plant growth under genetic control.

Explore possibility of utilizing hypoploids to move exotic, day-length sensitive germplasm into corn belt maize. Hypoploid plants from crosses of Tuxpeno, La Posta, and Zapalote Chico by TB-1La proved to be little earlier than their normal sibs, so such hypoploids will not be useful to expedite incorporation of exotic germplasm into corn belt lines.

Over 500 ears of the trisomes (1-10) in three inbred backgrounds (W23, 38-11, and Kys) were studied along with disomic sibs. The findings can be summarized briefly. The main effect of trisomy is to shorten the ear length. In some trisomes, such as 7, there is marked decrease in row number. In trisomes 1 and 2, there is a marked reduction in cob width.

Sorghum:

Physiological research - Lincoln, NE. Stress resistance of selected sorghum genotypes was tested on sandy soils of western Nebraska on a sprinkler irrigation gradient. Selections from population NP9BR were included which were screened for seedling drought resistance and which had higher stress stability on the irrigation gradient in 1977. There was no significant correlation between seedling drought resistance and yield stability with increasing drought stress.

Forty-eight advanced agronomic hybrids and eight selected yellow hybrids were grown on the gradient. Yield reductions from the wet to dry side ranged from 15 to 74%. The irrigation gradient was shown to be an effective method of selecting genotypes for yield stability to drought stress.

Sorghum was grown to maturity in hydroponic cultures with water stress controlled by additions of polyethylene glycol. As previously found, a root media stress of -6.5 bars during panicle development reduced yields 40 to 50%. A different response was found to stress at bloom. If stress occurred during early bloom, photosynthesis was severely inhibited and yield reduced about 30%. If the stress occurred during late bloom, neither photosynthesis nor yields were significantly reduced.

Relatively fast methods were developed to screen sorghum genotypes for Al tolerance and for N, P, and Fe efficiency. Optimum conditions for Al tolerance screening were 148uM AL, 64uM P, 7.4 mM Ca, 1.6 mM Mg, and 28/23 C day/night temperatures with good responses within 10 days after treatment. Aluminum toxicity ratings and root lengths were used to evaluate 93 genotypes. Ranges in dry matter yields and dry matter produced per unit of N values among genotypes were 2.9 fold and 36%, respectively.

Evaluating breeding systems - Lincoln, NE. Hybrid grain sorghum seed production was determined using 9 male-sterile lines and their 36 male-sterile single crosses. The F<sub>1</sub>'s averaged 47% greater seed yield per unit of land area than the lines due primarily to more and heavier seeds per plant, a higher threshing percentage, and more tillers per plant. Seed cost of three-way hybrids should be correspondingly reduced compared to seed cost of single cross hybrids.

A combine-height A-B genetic tester stock, SC102-9, dominant for Dw<sub>1</sub> and recessive for the other three major height genes has been identified. This stock should aid breeders in identifying lines with appropriate heights for both grain and forage hybrids.

Yield gains were made in C<sub>1</sub> populations over C<sub>0</sub> populations using half-sib, full-sib, and S<sub>1</sub> progeny testing in NP3R, but no gains were made in C<sub>2</sub> cycle over C<sub>1</sub>. Additive genetic variance was maintained in C<sub>1</sub> families compared with C<sub>0</sub> families while dominance variance disappeared.

S<sub>1</sub> progenies from mass-selected C<sub>0</sub> and C<sub>1</sub> populations of NP7BR selected for high and low grain protein were grown 2 years. Significant gains of 0.4% protein were made in both directions while yield was unchanged within populations.

Cytogenetics and genetic investigation - Gainesville, FL, Lincoln, NE, and College Station, TX. Search for alternative male sterility sorghum cytoplasms, thus possibly establishing a broader cytoplasmic base for hybrid production. Sixteen sorghum cytoplasms were split into six different male sterile groups, using restriction endonuclease fragment analysis.

Test crosses of the KS34-39 A-lines (male steriles) and a set of male lines were grown for sterility checks. Some lines exhibited high sterility with hegari and shallu males, indicating that they might differ from milo in cytoplasms. Several elite B lines are being converted to the A<sub>2</sub> system.

The sorghum line R473 has been shown not to be an obligate apomict and if it is a facultative apomict it has only a low frequency of asexual seed formation.

Host-plant resistance to pest organisms - Tifton, GA, West Lafayette, IN, and College Station, TX. Collections of shattercane (Sorghum bicolor) seeds from the U.S. corn and sorghum belts were analyzed for susceptibility to Periconia circinata, causal agent of milo disease, and its selection pathotoxin. In grain sorghum, a single incompletely dominant gene (Pc) determines susceptibility. One collection contained a portion of seeds that was susceptible to the pathogen and to its toxin. All other collections of shattercane were resistant.

Sorghum lines in progeny from controlled crosses were identified that are homozygous susceptible to P. circinata and heterozygous for a translocated chromosome. These lines should be the basis for the derivation of lines homozygous for a translocated chromosome.

Host resistance to both oospores and conidia of sorghum downy mildew was expressed in the same manner. The pathogens rate of spread from point of entry, in roots or leaves, was slower in resistance cultivars than in susceptible ones.

## Technological Objective 2.

New and improved cultural and management practices that increase corn, sorghum and millet yields, minimize production losses, improve quality attributes, and conserve and use scarce resources efficiently.

## Research Locations:

7700	Tifton, Georgia
3302	West Lafayette, Indiana
7400	Mississippi State, Mississippi
3608	Brookings, South Dakota

Selected Examples of Recent Progress:

Cultural and management practices - Tifton, GA, West Lafayette, IN, Mississippi State, MS, and Brookings, SD. Three sorghum hybrids each produced ■■ much or more grain when planted in mid-July than any of several corn hybrids, containing exotic germplasm, which we tested. Sorghum may be ■ better choice as a second crop in a double-cropping system than is corn when grain is harvested.

Stress effects on corn plants, induced by drought and/or mechanical injury to the ear, produced corn with significantly more aflatoxin than on their unstressed counterparts. Toxin contamination of corn may be capable of being significantly reduced by proper management and cultural practices.

Nitrapyrin improved the recovery of nitrogen fertilizers applied to corn and sorghum fields under wet soil and leaching conditions. The fertilizer additive preserved the availability of nitrogen for plants, increased yield and protein production and reduced the severity of several plant diseases. The decrease in disease severity and increase in yield while providing more protein increased farmers profit by more than \$20 per acre.

There are ■ number of ways to demonstrate the value of proper hybrid selection. In Mississippi, the five highest performing hybrids in yield trials averaged 18 to 23% higher than the average of all hybrids in the trials. Certainly, proper corn hybrid selection is an important management decision.

Rootworm infested corn production plots under three levels of nitrogen (N) and three levels of supplemental irrigation were studied over 4 years. There was ■■ increase of 7 bushels due to irrigation and 8 bushels due to added N. These increases were not related to insecticide treatment. The rootworm population (emerged adults/plant) dropped from 110 to 4 in the untreated plots. This study demonstrated the extreme variation in effect of rootworm damage that exists from season to season and from plot to plot when working with natural field populations.

A 3-year study of small grain tillage practices involving 10 treatments, including time of plowing, herbicide treatments and burning, showed there were no appreciable differences in emerged insect numbers among treatments where corn was planted the following year. It is important to note that both the northern and western rootworm laid eggs in the different fall treatments. This study indicates that the tillage of small grain stubble is not the determining factor in first year corn damage for either species of rootworm.

VARIETIES RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
<u>CORN</u>		
B84	SEA-Iowa AES	Good yield, from BSSS(S2)CO
A632Rp	SEA-Iowa AES	Rust-resistant strain
A635Rp	SEA-Iowa AES	Rust-resistant strain

NONCOMMERCIAL GERMPLASM RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
<u>CORN</u>		
NCIR10	SEA-North Carolina AES	Selected for high grain yield
NCJR10	SEA-North Carolina AES	Selected for high grain yield
B85	SEA-Iowa AES	First-Brood corn borer resistance, early-maturity
<u>SORGHUM</u>		
PR4BR	SEA-Puerto Rico & Texas AES	For breeding primarily in the tropics

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National Research Program 20050

BREEDING AND PRODUCTION - SMALL GRAINS (WHEAT, OATS, BARLEY, RICE, RYE, TRITICALE, WILD RICE, BUCKWHEAT)

This National Research Program involves research in breeding and production of the cereal small grains to develop new and improved genetic and cultural methods that will result in lower costs to consumers and increased efficiency of production for growers. Research agronomists, geneticists, plant pathologists, plant physiologists, cereal chemists, and other scientists work in a team approach to evaluate and improve small grain varieties and improve cultural methods.

NPS Contact: L. W. Briggles

Technological Objective 1.

New and improved genetic populations, breeding lines, and varieties of small grains that combine greater yield potentials and favored quality characters, including reduced contents of undesirable constituents, with better resistance to pests, tolerance to environmental stress, responsiveness to new cultural and management practices, and adaptation for mechanized culture, harvesting, and handling.

Research Locations:

3611	Palmer, Alaska	5708	Bozeman, Montana
5502	Tucson, Arizona	3416	Lincoln, Nebraska
7406	Stuttgart, Arkansas	3602	Fargo, North Dakota
5206	Davis, California	3307	Wooster, Ohio
7602	Gainesville, Florida	7317	Stillwater, Oklahoma
5703	Aberdeen, Idaho	5809	Corvallis, Oregon
3311	Urbana, Illinois	1302	University Park, Pennsylvania
3408	Ames, Iowa		
3420	Manhattan, Kansas	7617	Mayaguez, Puerto Rico
7410	Crowley, Louisiana	3608	Brookings, South Dakota
1108	Beltsville, Maryland	7303	Beaumont, Texas
3508	East Lansing, Michigan	5702	Logan, Utah
3502	St. Paul, Minnesota	5802	Pullman, Washington
3402	Columbia, Missouri	3507	Madison, Wisconsin

Selected Examples of Recent Progress:

Small Grains in General:

Seed increase - Aberdeen, ID. Over 14,000 single or multi-row plots and about 1,400 spaced plants of oats, barley, and wheat were grown for 21 SEA/AR and AES projects located in 15 States in 1978. Included were portions of the World Small Grains Collection and future entries for the International Rust Nurseries.

Seed increase - Obregon, Mexico. About 16,422 durum and hard red spring wheat selections and genetic lines were grown in the winter increase program conducted cooperatively by SEA/AR and the Crop Quality Council, Minneapolis, Minnesota. This service is provided to small grains research personnel in the spring grain area (North Dakota, South Dakota, Minnesota). Use of this winter nursery allows an advance of an extra generation per year toward homozygosity, additional selection for favorable characters and disease resistance, plus seed increase for yield and quality tests. The program is administered through the Minnesota-Wisconsin-Michigan SEA/AR Area Office.

Variety and germplasm releases - U.S. Seven wheat, one barley, and one rice varieties were released cooperatively by SEA/AR and the State Agricultural Experiment Stations in 1978. One wheat, one barley, and 13 oat germplasm populations were released by the same agencies in 1978.

Special nurseries - Beltsville, MD. Three international and five uniform wheat and oat nurseries, consisting of 1,091 entries, were prepared in 1977 and distributed to 140 locations in 45 countries for determining reactions to different biotypes of disease-producing organisms. In addition, two more wheat international nurseries were distributed from Lincoln, Nebraska, and approximately 20 uniform nurseries involving wheat, oats, barley, and rice were distributed within the U.S. from project locations other than Beltsville. Most of the latter are performance nurseries where advanced breeding lines are tested for characters such as yield, disease resistance, and lodging resistance.

#### Wheat:

Components of nonspecific resistance (NSR) to leaf rust assessed in 42 genotypes - Gainesville, FL. Seven genotypes had low infection rates; five had significantly longer latent periods (2 to 5 days) than susceptible types. The objective of this research is to improve resistance in wheat to fungal pathogens.

New wheat varieties provide disease resistance - Aberdeen, ID. 'Arbon,' hard red winter wheat has resistance to dwarf bunt (TCK) governed by genes from a different source than those in other commercial varieties. Genetic diversity for resistance will reduce the danger of bunt epidemics, thus stabilizing wheat production and helping to reinstate export of Pacific Northwest wheat to the People's Republic of China. 'Dirkwin,' soft white spring wheat, improves the level of protection against prevalent races of mildew and leaf rust in Idaho and Oregon.

Quality testing of Hard Red Winter Wheat breeding lines - Manhattan, KS. About 1,275 early-generation samples were analyzed for grain protein. Some were micro-milled to determine milling quality. Several were from 1.5 to 3.8 percentage points higher in protein than checks included. About 470 samples of agronomically promising new lines and recent releases were characterized for milling and baking properties. About 29 percent had good milling, chemical, breadmaking, and physical dough properties. Leading commercial varieties of tomorrow are among them.

During the years 1975-78, average wheat yield in Kansas was higher than in 1965-68, and grain protein was 0.2 percent higher. The recognized gradual decline in grain protein apparently has been halted and reversed during the past few years, largely through growing high protein 'Eagle' and other new varieties.

Successful wheat anther culture - Beltsville, MD. A system to develop haploid wheat callus, which in turn can be regenerated into plants, has been developed. Haploid plants thus produced have been doubled through use of colchicine, and some of these plants have produced seed.

New sources of disease resistant germplasm found - Beltsville, MD. Stem rust and powdery mildew resistant lines were identified. An elite set of 114 selections resistant to mildew was established and distributed. Over 12,000 accessions from the World Wheat Collection were tested with a composite of cultures of the causal organism; those lines resistant were evaluated further in the field at several locations; those resistant in the field were tested with additional cultures.

Elimination of yellow-flour gene makes use of *Agropyron* leaf rust resistance practicable - Columbia, MO. Previous transfers of leaf rust resistance to wheat from a chromosome of *Agropyron elongatum* (a wild relative of wheat) imparted an undesirable yellow flour color. Recent identification of two non-yellow flour lines which represent transfers of resistance will permit use of this resistance in commercial varieties.

Two new Hard Red Winter varieties released - Lincoln, NE. 'Bennett' is a moderately short variety that combines resistance to stem rust and soil-borne mosaic with high yield, improved straw strength, and good baking quality. 'Centurk 78' is similar to Centurk in agronomic and quality traits but has been consistently more productive. A third variety developed in the SEA/AR - University of Nebraska program, 'Capitan,' was released by the New Mexico Agricultural Experiment Station.

Quality testing of Hard Red Spring and Durum wheat - Fargo, ND. Quality evaluation tests were performed on 1,246 samples of hard red spring wheat and 607 samples of durum. HRS samples came from 6 States and durum samples from 7 States. An additional 21 large-scale Crop Quality Council HRS lots were processed for evaluation by the Laboratory and by industry participating collaborators.

Dual purpose mill reduces equipment cost and space requirements - Fargo, ND. An experimental flour mill originally designed to produce bread wheat flour was modified to produce farina for breakfast cereals, semolina for pasta products, and flour for bread products. A cut-off valve was designed to simplify the change-over. Purifier surface was increased by 300 percent. Production of different types of cereal products by such utilization of milling equipment available can reduce equipment, space, and energy costs.

New wheat line resistant to Greenbug - Fargo, ND. A hexaploid wheat was synthesized from a cross involving Langdon durum (28 chromosomes) and *Triticum tauschii* (14 chromosomes). The latter parent was formerly designated as *Aegilops squarrosa*, and is a wild grass relative of wheat. The

new wheat line crosses readily with other hexaploids and is highly resistant to the Greenbug.

Quality testing of Eastern Soft Red Winter and Soft White Winter wheat - Wooster, OH. More than 3,600 samples from breeding programs and uniform performance nurseries were tested for soft wheat milling and baking quality. This included small-size early generation samples as well as larger samples from advanced lines.

Brewer's spent grain (BSG), a by-product of brewing, can add fiber and protein through incorporation in cookies. Cookie quality is reduced, however, but this can be counteracted through use of emulsifiers. Drying BSG at higher temperatures has a positive effect on cookie quality.

Cake volume was improved without flour chlorination if lipids were extracted from flour, adsorbed on diatomaceous earth, heated under controlled conditions, eluted, and added back to flour. Lipids from bran are as effective. Since bran is higher in extractable lipids and is less expensive than flour, this milling by-product could be a source of lipids.

New technique allows breeders to simultaneously test lines for resistance to both common bunt and dwarf bunt - Corvallis, OR. Cultures of bunt which carry new combinations of genes for virulence have been developed. These new cultures cause smut in wheats previously classed as resistant. Use of the new cultures in selecting wheats for resistance should expedite development of new lines or varieties to all known races of both bunts.

Model for definitive identification of dwarf bunt spores - Logan, UT. This model was developed from statistical analysis of data obtained from microscopic examination of numerous collections of bunt spores from wheat and wild grasses. The model utilizes measurements of a few key spore characteristics and has demonstrated 92 percent accuracy in distinguishing wheat bunt spores from those of other bunt fungi in initial evaluations. Accurate identification is of critical importance in assessment of dwarf bunt contamination in wheat for export to the People's Republic of China.

Quality testing of Western wheats - Pullman, WA. Complete milling and baking evaluations were conducted on 939 samples; 1,682 F<sub>3</sub> - F<sub>5</sub> samples were evaluated via small-sacle tests for milling and baking; 260 grain samples from single plants were micro-milled; 1,000 early-generation lines were screened for protein and lysine through use of the near infrared reflectance (NIR) equipment.

Japanese sponge cake and Japanese noodles highly sensitive to alpha amylase in sprouted wheat - Pullman, WA. Correlation between sponge cake score and alpha amylase activity measured by the Falling Number test was .99 when evaluating constructed blends from sprouted grain and sound grain. As little as .3 percent sprouted wheat was sufficient to be detrimental to sponge cake quality. Up to 1.5 percent sprouted grain could be added before detrimental effects on noodle quality were evident.

Slow rusting involving leaf rust and nonspecific resistance to stripe rust varieties - Pullman, WA. Leaf rust infection on five local varieties is characterized by a longer latent period, fewer sites of infection, fewer spores produced, and a range of infection types compared to "fast" rusters. Resistance is slightly race specific. A different group of varieties has nonspecific resistance to stripe rust (highly susceptible in the seedling stage but more resistant at high temperatures and more advanced growth stages).

Genetic control of tolerance to *Cercospora* foot rot - Pullman, WA. This foot rot is the major soilborne disease of wheat in the Pacific Northwest. A broad genetic base for tolerance is available among wheats from Northern Europe. Breeders hope to achieve even higher levels of tolerance by intercrossing tolerant parents and selecting superior progenies.

#### Oats:

Nonspecific resistance (NSR) to crown and stem rust - Gainesville, FL. Rates of spread of oat crown rust from plot centers were 0.35, 0.4, and 0.9 meters/day for resistant, intermediate, and susceptible varieties. When the oat stem rust pathogen was used, leaves of varieties with a high degree of NSR did not express slow rusting, but the number of pustules on stems was significantly lower than on susceptible types. Varieties with NSR produced fewer spores on infection sites than did susceptible types. These results suggest that NSR to oat stem rust is a physiological effect.

Introduction of genes from wild oats (*Avena sterilis*) reduces disease vulnerability of common oats - Urbana, IL. Oat breeding lines were developed with divergent sources of resistance (and higher levels of resistance) to provide a broader spectrum of protection against two of the most important oat diseases, crown rust and yellow dwarf virus.

Leafhopper *Endria inimica* vector of wheat striate mosaic virus, does not transmit oat striate virus - Urbana, IL. Specific transmission of the two viruses provides additional evidence for their distinctness, despite similarity of symptom expression. Oat striate virus is a new rhabdovirus which is transmitted specifically by another leafhopper, *Graminella nigrifrons*.

Effect on crown rust on harvest index of oats - Ames, IA. Harvest index is the ratio of grain to straw, and is known to vary among varieties. The effect of crown rust on this ratio was measured for 110 genotypes by comparing harvest indexes in rusted and in noninfected plots. The disease in most cases, but not all, resulted in a lower percentage of grain relative to straw. The effect of crown rust on harvest index is highly heritable; new lines probably could be developed with a more desirable harvest index response to rust infection.

Increased frequency of callus cultures from oat anthers - St. Paul, MN. Treatment conditions and media composition were determined and two varieties identified which gave rise to callus cultures at a frequency of 5 to 15 percent of anthers plated. This is marked progress over previous rates of 0.06 percent. No haploid plants have yet been regenerated from oat anthers.

Improved winter oat variety reduces losses from winterkilling - University Park, PA. 'Pennwin' winter oats was developed by SEA/AR and Pennsylvania State University and released in 1972. It was released to Virginia seed growers in 1978 for certified seed production in that State. Pennwin has a 5 percent better survival score and a 9 percent higher yield over a 4-year period than the best commercial variety, 'Norline.' Such improvements in winterhardiness and yield are important for stable production of winter oats in northern areas.

Genetics of dwarfness in oats - University Park, PA. C. I. 8447 is a compact-panicle, stiff-straw, short oat that has considerable value as a parental source for short stature. In crosses with "conventional" oats, dwarfness is transmitted by a single, partially dominant gene, plus modifying genes with minor effects. Development of semidwarf varieties of intermediate height should be possible. Such varieties would reduce losses from lodging and allow more intensive management for high yields.

Quality testing of oats - Madison, WI. In 1978, 23,663 oat groat samples were analyzed for protein at the National Oat Quality Laboratory. These are primarily breeders samples from programs where efforts are directed toward development of high protein varieties.

Biochemical and cytological characterization of protein body development in oat grain - Madison, WI. As revealed by electron microscopy, protein bodies of the starchy endosperm originate within the endoplasmic reticulum and grow by coalescence within vacuoles. By contrast, aleurone grains first appear within double membranes--suggesting a plastid origin.

#### Barley:

Release of composite cross as germplasm - Tucson, AZ. CCXXXII-78 is a bulk of male-fertile F<sub>2</sub> plants that were selected from various short-straw populations. These populations came from continued recurrent selection within CCXXXII and from mass backcrossing new germplasm sources into CCXXXII. CCXXXII-78 has a much higher frequency of agronomically desirable plants than the original CCXXXII. Primary areas of improvement are increased range of adaptation, seed size, and lodging resistance.

Numerous seedlings from CCXXXII-78 were evaluated for coleoptile length, as were seedlings of standard varieties and lines, plus varieties and lines originally selected from CCXXXII. Based on those measurements, short straw in CCXXXII-78 is not associated with short coleoptile. Stand establishment difficulties encountered with semidwarf wheats should not plague new short-straw barley varieties developed from this germplasm source.

New 6-row feed barley with improved lodging resistance released - Aberdeen, ID. 'Steve' is superior to presently grown varieties in resistance to lodging and is lower in hull percentage than the most widely grown and highest yielding variety, 'Steptoe.' It yields nearly as much as does Steptoe.

Bacterial toxins have deleterious effect on winterhardiness of winter barley and other winter cereals - East Lansing, MI. Toxins developed in freeze-killed roots during recovery of plants and impaired crown meristems. This resulted in decrease of cold hardiness. The toxicity was principally of bacterial origin rather than autotoxicity from nonmetabolic chemical reaction or autolysis by released cell enzymes. Control of the bacteria could result in significant increase of winterhardiness.

Research on male sterility in barley - Bozeman, MT. New loci for male sterile genes were designated msg 29a, msg 30c, msg 31d, msg 32w, and msg 33x. Three of these are allelic with previously numbered loci. Data from segregating and selfed progenies were obtained on 13 new genetic male-sterile mutants.

Male sterility and female fertility of a cytoplasmic male sterile line of barley were confirmed. This source of male sterility was found in Finland. Effective restorers are not yet available.

Latex serological test adaptation - Fargo, ND. This test was adapted for use in detecting presence of barley stripe mosaic virus (BSMV) in dry seed. The time required to determine presence of the virus was reduced to 15 minutes (from 2 hours). An unskilled person can utilize the test after a 2-3 hour training session. This procedure will eliminate the need to grow new barley introductions for detection of the virus.

Quality testing of malting barley - Madison, WI. A total of 3,400 grain samples from 12 barley breeding programs were evaluated for 8 malt and 4 barley characteristics.

Effect of barley on cholesterol in blood of chickens - Madison, WI. Chicken rations containing substantial amounts of small grains (barley, oats, wheat, or rye) lowered the concentration of liver enzymes which synthesize cholesterol, and lowered the concentration of cholesterol in the blood. Barley produced the greatest effect. Addition of very low concentrations of a product from the mold *Trichoderma viride* enhanced cholesterol reduction.

#### Rice:

Release of very early, cold-tolerant, short stature variety - Davis, CA. M-301 was released for production in the cooler areas of California and for late seeding. It is highly resistant to lodging, and yields 10 percent more than the variety it is expected to replace. The greater yield can increase return per acre about \$50.

Quality testing of rice - Beaumont, TX. More than 11,000 breeding lines were evaluated for amylose content, alkali spreading value, parboil canning stability, paste viscosity, and grain protein. In addition, over 3,000 new introductions grown at El Centro, California, were evaluated.

Introduced Chinese rice varieties are high yielding - Beaumont, TX. Two Chinese varieties produced high yields in a very short time--99 days from<sub>2</sub> seeding to harvest. Five Chinese varieties produced 60 to 65 grams/day/m<sup>2</sup>, a level reached by no other entries in the test. The high productivity and very short growing season of these varieties may prove very useful in U.S. breeding programs. By our standards, the grain appearance, milling, and cooking quality of the Chinese varieties are unacceptable.

Breeding for resistance to rice blast (*Pyricularia oryzae*) - Beaumont, TX. F<sub>3</sub> lines from two segregating populations were identified as having resistance to all current races of the causal fungus.

There was no downward trend in field resistance to blast among new varieties compared to older ones when 19 varieties with release dates ranging from 1928 to 1976 were compared. Ratings given F<sub>3</sub> and F<sub>4</sub> lines of a particular cross indicated high heritability of field resistance.

## Technological Objective 2.:

New and improved cultural and management practices that increase small grain yields through disease, insect, and weed control; that minimize environmental stress; that improve physical and nutritional quality attributes; that minimize production losses; and that conserve and more efficiently use scarce or irreplaceable resources.

## Research Locations:

3611	Palmer, Alaska	1302	University Park,
7602	Gainesville, Florida		Pennsylvania
5703	Aberdeen, Idaho	3608	Brookings, South Dakota
3311	Urbana, Illinois	7303	Beaumont, Texas
3420	Manhattan, Kansas	5702	Logan, Utah
3416	Lincoln, Nebraska	5802	Pullman, Washington
5809	Corvallis, Oregon	3507	Madison, Wisconsin

## Selected Examples of Recent Progress:

### Wheat:

Epidemiology and ecology of leaf rust (*Puccinia recondita*) on wheat - Manhattan, Kansas. In a special study involving three wheat near-isogenic lines (Thatcher-susceptible; LR 16 Thatcher, and LR 18 Thatcher) at three temperatures (15.6°C, 21.1°C, and 26.7°C), there was no significant difference between number of urediospores produced at 21.1°C and 26.7°C over the three varieties. Number of urediospores produced at 15.6°C was significantly lower than at 21.1°C or 26.7°C. Most urediospores were

produced on Thatcher, and the least on LR 16 Thatcher, over all three temperatures. No significant difference in incubation periods occurred among host-parasite combinations at 20-25°C. Incubation period was lengthened at temperatures below 20°C by 48 hours for every 5°C reduction in temperature. At 10°C, one host-parasite combination produced no sporulation within 400 hours.

Wheat streak mosaic virus in corn - Lincoln, NE. About 50 corn lines were screened for susceptibility. There were more susceptible early maturing lines than those of medium or late maturity. Maize dwarf mosaic virus was recovered (by manual inoculation) from 39 of 40 corn plants and wheat streak mosaic virus from 12. Plants with both viruses usually showed a yellow mosaic pattern, but plants with one virus had a yellow, green, or no mosaic. Golden bantam sweet corn infected with maize dwarf mosaic virus was susceptible to wheat streak mosaic virus. This sweet corn is generally resistant to wheat streak mosaic virus. Synergism is a possible explanation.

Soilborne wheat mosaic virus vector observed - Lincoln, NE. Root pieces containing *Polymyxa graminis* resting spores proved resistant to cell wall digesting enzymes. Glutaraldehyde fixed and rinsed tissue pieces could be digested and resting spore clusters varying widely in size were free in the medium. Spore clusters could not be isolated with density gradient techniques.

Two new endogenous germination inhibitors from dwarf bunt spores - Corvallis, OR. The two new inhibitors were purified by high pressure liquid chromatography, using two reverse-phase C-18 columns and many different elution profiles. Eluants were monitored by absorbance at 218 nm and bioassayed by a spore germination test. The compounds were labile, and inhibitory activity was lost in final stages of purification. Improved new procedures for extracting the inhibitors and protecting them from chemical alteration during purification steps are being developed, as are new bioassays for very small volumes.

Effects of planting date on efficacy of seed treatment fungicides for control of dwarf bunt - Logan, UT. In tests conducted with three systemic fungicides, three wheat varieties, and three dates of seeding at each of three locations, fungicide effectiveness was significantly greater if planting was delayed until after October 15, compared to September 15 or October 1. Excellent control of dwarf bunt was obtained even in highly susceptible 'Wanser' with thiabendazole at 4 oz/bu.

Plant disease may be reason for poor yields in no-till - Pullman, WA. Discovery that *Pythium* is responsible for poor stands or stunting of plants seeded under no-till, and that a fungicide will control the problem, is a major breakthrough for no-till farming and erosion control in the annual-cropped areas of eastern Washington and adjacent areas of Idaho. It should be possible to grow wheat at full production levels without tillage if diseases and weeds can be controlled.

Germplasm for adaptation to conservation tillage methods - Pullman, WA. Tests with several hundred wheats grown under conventional, no-till, and minimum-till management with three different types of crop residue showed that an array of plant types may be suitable for conservation tillage systems. Wheats that yielded highest under conventional tillage usually were the highest yielders under conservation tillage as well. Medium early types appeared best adapted to no-till, but no single height plant type performed well in all tests. Even some short semidwarf types did well if downy brome was controlled. Volunteer grain must also be controlled.

Important factors identified for sprout resistant wheats - Pullman, WA. Varieties that will not sprout in the field when rains occur just before harvest are needed in the Pacific Northwest. Tests involving more than 100 wheat selections indicate that resistance to sprouting is mainly seed dormancy, but other factors such as closed florets, low alpha amylase activity, early maturity, lax spikes, tight glumes, medium plant height, and short awns or no awns, enhance resistance to sprouting.

#### Oats:

Management practices for semidwarf oats - University Park, PA. In a nitrogen response study on an experimental, compact panicle, semidwarf oat, premature loss of leaf area reduced yield. Increasing N from 44.8 to 112.1 kg/ha resulted in an 8 q/ha yield increase. In other tests, weekly applications of water and nutrients did not prevent loss of leaf area. Loss of leaf area before grain filling is complete continues to be a problem in semidwarfs.

Size of vascular tissue below panicle related to grain yield in preliminary study - Madison, WI. Vascular bundle area, vascular bundle number, or phloem area in that part of the culm below the panicle, was highly correlated with groat number and yield among several panicles from two varieties, when plants were produced in a growth chamber.

#### Barley:

Influence of management practices on incidence of bacterial blight in barley - Aberdeen, ID. Percent of infected kernels in 75 farm-field samples of 1977 crop 'Klages' ranged from 0 to 6.3 percent. Incidence of infection was higher when potatoes preceded barley, compared to barley preceding barley. Incidence was also higher under sprinkler irrigation when compared to gravity irrigation.

#### Rice:

Short stature rice more susceptible to sheath blight - Beaumont, TX. Yield reductions caused by sheath blight, *Rhizoctonia solani*, were greater for short stature lines than for standard height varieties (25 percent and 11 percent reductions, respectively). Milling yields were reduced by sheath blight, but losses were not associated with plant height nor yield reduction.

# VARIETIES RELEASED

<u>Name or Designation</u>	<u>Class or Type</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
<u>WHEAT</u>			
Cheney	Hard Red Winter	SEA-Kansas AES	Resistant to soilborne mosaic and stem rust
Dirkwin	Soft White Spring	SEA-Idaho AES-Oregon AES	Improved leaf rust and mildew resistance
Centurk 78	Hard Red Winter	SEA-Nebraska AES-New Mexico AES	Similar to Centurk in agronomic and grain quality traits but consistently higher yielding
Angus	Hard Red Spring	SEA-Minnesota AES	Resistant to the prevalent races of stem rust. Has a broader spectrum of resistance to leaf rust than Chris or Era. Has higher grain protein than Era.
Wampum	Hard Red Spring	SEA-Washington AES-Idaho AES	Resistant to local races of leaf rust in the adult plant stage. Resistant to some races of common bunt.
Arbon	Hard Red Winter	SEA-Idaho AES	New source of resistance to dwarf bunt
Bennett	Hard Red Winter	SEA-Nebraska AES	Moderately short, combines resistance to stem rust and soilborne mosaic with high yield, improved straw strength with good baking quality

<u>Name or Designation</u>	<u>Class or Type</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
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BARLEY

Kimberly	Two-row spring malting	SEA-Idaho AES- Oregon AES	Similar in agronomic and malting quality characteristics to Klages but higher in yield
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RICE

M-301	Medium-grain	SEA-California AES- California Co-Op Rice Research Foundation	Early, lodging resistant, 10 per- cent higher yield than variety it will likely replace
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NONCOMMERCIAL GERMPASM RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
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WHEAT

Exile	SEA-Oklahoma AES	Genetic background for specific genes for leaf rust resistance
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BARLEY

Composite Cross XXXII-78	SEA-Arizona AES	Higher frequency of agronomically desir- able plants than original CCXXXII--in- creased range of adaptation, larger seed, increased lodging resistance
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OATS

13 Yellow Dwarf Tolerant Oats	SEA-Illinois AES	Highest level of tolerance to BYDV in oats currently available
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## National Research Program 20060

### BREEDING AND PRODUCTION - COTTON

Cotton fiber, and food and feed from cottonseed are vital renewable national resources. Domestically produced cotton fiber reduces our dependence on petroleum based synthetics. The mission of this national research program is to develop new knowledge which will increase production efficiency and provide consumers with a stable supply of fiber and food at a reasonable cost. The research approaches emphasize genetic improvement and the development of more efficient cultural and management practices.

NPS Contact: P. A. Miller

#### Technological Objective 1.

New and improved genetic populations, breeding lines, and varieties of cotton that combine increased yield potentials and favored quality characteristics of seed and lint with increased resistance to pests, tolerance to environmental stresses, and adaptation to modern cultural, harvesting and handling practices.

#### Research Locations:

7506	Auburn, Alabama
5510	Phoenix, Arizona
5206	Davis, California
5203	Shafter, California
7502	Mississippi State, Mississippi
7402	Stoneville, Mississippi
5507	Las Cruces, New Mexico
7802	Raleigh, North Carolina
7709	Florence, South Carolina
7806	Knoxville, Tennessee
7203	Brownsville, Texas
7302	College Station, Texas
7311	El Paso, Texas
7313	Lubbock, Texas
7200	Weslaco, Texas

#### Selected Examples of Recent Progress:

#### Basic Genetics and Germplasm Resources:

Semigametic stock with male sterility simplifies production of haploids - Phoenix, AZ. Semigamy is a genetic mechanism originally discovered by AR researchers which facilitates the production of haploid plants having one-half the normal chromosomal complement. Doubling of the chromosome number, which may occur spontaneously or by chemical treatment, results

in genetically pure strains of cotton in one generation. Standard breeding methods require six to eight generations of inbreeding to produce pure lines. A male sterile semigametic stock was developed which eliminates the need to emasculate prior to crossing when the semigamy system is utilized to develop pure lines in one generation.

Cotton germplasm resources expanded - Mississippi State, MS. The collection of wild cottons has been shown to carry genes for resistance to insect and disease pests. However, most of these accessions are photoperiodic and will not flower in the Cotton Belt. Seed of 81 germplasm lines which will flower in the Cotton Belt were developed by crossing (in the tropics) fifty-four of these accessions to U.S. varieties, and growing and selecting within the segregating generation in Mississippi. These seed were released to public and private breeders and are sources of genes for moderate resistance to the boll weevil, tolerance to Verticillium wilt, and resistance to Cercospora leafspot. These released germplasm lines will allow breeders to evaluate this material in the Cotton Belt and use it in their varietal improvement programs.

Cell culture and plant regeneration methods under development - Las Cruces, NM. The capacity to grow callus and liquid suspension cell cultures of cotton has been developed, including the induction of haploid cell lines from anther cultures. This past year techniques were worked out for producing proembryos. This is a significant and major step necessary for the regrowth of cotton plants from cell cultures. Once mature embryos are produced, plant regeneration is then possible and the cell culture system for cotton would be ready for use as a research tool. This would provide new approaches for genetic manipulation and selection for improving cotton varieties.

Cross-incompatible cotton strain tested - Raleigh, NC. Genes for cross incompatibility in cotton were transferred from a wild species into a glandless experimental strain. Although the glandless strain was planted in a nursery surrounded by normal glanded cotton, no outcrossed glanded seed were produced. This genetic isolating mechanism could be useful in preserving the integrity of commercial crops of glandless cotton when these are grown in the vicinity of glanded material. (Glandless (gossypol-free) cottonseed are a potential source of high quality protein for human food and nonruminant animal feed.

#### Developmental breeding:

New sources of host plant resistance released - Auburn, AL. Four different traits (nectariless, smoothleaf, frego bract, and okra leaf) were each backcrossed into eight cotton varieties adapted to the Southeastern and Delta production regions. The 32 resulting lines were released as noncommercial germplasm. These four traits confer partial resistance to certain cotton pests. Nectariless reduces plant bug populations, smoothleaf suppresses egg laying by bollworms, frego bract may reduce number of boll weevils, and okra leaf decreases whitefly

infestations and boll rot. Applied breeders will be able to intercross among these adapted lines to obtain varieties with desired agronomic and pest resistant character combinations.

Nectariless cottons shown to reduce Lygus damage in the Irrigated West - Shafter, CA. Nectaried Acala SJ-2 and its isoline, nectariless H6124, were grown in Lygus infested plots and plots where Lygus were controlled. The yield of the standard commercial variety Acala SJ-2 was reduced 25% in the Lygus infested plots, whereas the yield of the experimental nectariless line was reduced only 15%. The nectariless experimental strains averaged 6% more yield than the nectaried varieties.

Yellow pollen reduces bollworm larval growth - Stoneville, MS. Commercial cotton varieties may have either yellow or cream-colored pollen. Bollworm larvae fed on an artificial diet of yellow pollen were 13-15% smaller after seven days of feeding than those fed on cream pollen. This investigation indicates that yellow pollen has an inhibitory effect on developing tobacco budworm larvae.

Breeding lines for improved fiber quality and insect resistance released - Florence, SC. A germplasm release, Pee Dee 8619, incorporates new genes for improved lint quality, particularly increased tensile strength with high yield. Pee Dee 695, a frego bract line and Pee Dee 875, a normal bract line, have both shown partial resistance to the bollworm/budworm complex. These cottons produce normal cotton yields with about one-half the amount of insecticide recommended for current varieties.

Fiber and seed quality of experimental cotton breeding lines evaluated - Knoxville, TN. Approximately 9,200 samples were evaluated for fiber length, strength, elongation, and fineness; 8,500 samples for fiber color, length, fineness and yarn tenacity; and 1,700 for seed oil, nitrogen and free gossypol. These data were supplied to cooperating breeders at various locations across the entire Cotton Belt and provide the basis for developing germplasm with improved fiber and seed quality traits.

Experimental cottons developed with more favorable balance of flower bud and seed gossypol - Brownsville, TX. Crosses of adapted varieties with certain wild race stocks have produced progeny with higher bud gossypol but lower seed gossypol than the standard variety Stoneville 213. This is very desirable since high flower bud gossypol (a naturally occurring chemical in plants) confers resistance to many insect pests, but low seed gossypol is desired by the cottonseed crushers and processors. Current cotton varieties generally show a close and undesirable positive association between flower bud and seed gossypol content.

Genetically controlled traits identified which may confer drought resistance - Lubbock, TX. Detached leaves from different cotton genotypes were evaluated for stomatal behavior in the laboratory. Leaves from certain strains had lower cuticular transpiration rate and higher relative water content after stomatal closure than others. Replicated field tests of these genotypes in a semi-arid environment indicate that both of these traits are heritable.

#### Varietal Development:

Improved association of earliness and productivity with high fiber quality in Pima cotton - Phoenix, AZ. Fiber quality, especially fiber length and strength, is generally negatively correlated with productiveness. This relationship was partially counteracted with the development of the current commercial variety, Pima S-5. New experimental strains show an additional breaking up of this negative relationship. These strains, compared to Pima S-5, are as much as two to three weeks earlier, are more productive and have comparable fiber properties. An early, productive, short-statured cultivar is an essential part of the short season concept for reducing production costs and for more efficient pest management.

Applied Acala breeding program phased out - Shafter, CA. Since its inception over 40 years ago, the responsibility of this project was to breed and develop cotton varieties for the San Joaquin Valley of California. By State law, the USDA was given this exclusive right. A new State law effective January 1, 1979, now allows any public or private breeder this privilege. Because of this change, the USDA applied breeding project has been transferred to the private sector. Recent major accomplishments in the SEA-AR program include the release of the commercial variety Acala SJ-2 with an increase of 8 percent in yield over older varieties. Acala SJ-5 was released in 1977 because of its exceedingly high tolerance to Verticillium wilt. Both cultivars produce premium quality fiber. Over the life of this project many valuable breeding stocks were developed and distributed to breeders across the Cotton Belt. Seed of this entire germplasm (549 stocks) were made available to all public and private cotton breeders in the United States at the termination of this project.

#### Technological Objective 2.

New and improved cultural and management practices that optimize yield potentials, minimize production losses, preserve quality attributes, and conserve and utilize resources efficiently.

#### Research Locations:

7506	Auburn, Alabama
5510	Phoenix, Arizona
5203	Shafter, California
7502	Mississippi State, Mississippi

7402	Stoneville, Mississippi
7806	Knoxville, Tennessee
7203	Brownsville, Texas
7302	College Station, Texas
7313	Lubbock, Texas

#### Mechanisms of Growth Regulation:

Delay of first post-emergence irrigation conserves water and increases yield - Phoenix, AZ. Water for irrigation is becoming less available and more expensive. An experiment in which the date of first irrigation was varied indicated that delaying the first irrigation not only saves water but may also increase yield. Even though delaying the first irrigation caused severe wilting and retarded plant growth, these plants produced almost 14 percent more cotton than those that were irrigated early and they used less water.

Nitrogen nutrition effects drought tolerance - Phoenix, AZ. Nitrogen nutrition and water relation of cotton have been found to be intimately interrelated. Some of the structural characteristics of plants which confer drought tolerance can be induced by a nitrogen deficiency. Equally important, stomatal behavior is altered in a way which provides drought avoidance (stomates close sooner and prevent or minimize dessication). Both of these mechanisms increase overall drought resistance of N-deficient plants. These results provide a basis for the long-standing belief by farmers that excess fertilization can decrease drought resistance.

#### Cotton Diseases:

Occurrence and spread of the Verticillium wilt fungus studied - Davis, CA. Verticillium dahliae is one of the major diseases attacking cotton. Greasewood, a native shrub widely distributed in the West, was shown to be susceptible to the fungus and may constitute an important reservoir of the disease in virgin soils. Furthermore, it was observed that the Verticillium wilt fungus may be present in seed of Russian thistle and cocklebur growing under field conditions. These findings are important in determining the role of these plants in the occurrence and spreading of Verticillium wilt in agricultural districts.

Biochemistry of pest resistance - College Station, TX. Major antibiotic metabolites in cotton have been identified. The structure, quantity, and localization of these metabolites and the speed of their induced biosynthesis, have been determined in relation to the resistance of tissues and varieties of cotton to diseases and pests. The genetic control of secondary metabolites has been determined and is being used in breeding for disease and pest resistance in cotton.

Nature of genetic variability in Verticillium wilt described - College Station, TX. Techniques were developed for determining genetic relationships in Verticillium wilt. Four different genetically isolated populations were demonstrated. Each population had similar physiological and pathogenic properties. All isolates of Verticillium that were highly virulent to cotton belong to the population P-1. The identification of populations provides a better understanding of genetic variability and the origin of pathotypes. Also, it gives direction in breeding for disease resistance.

Biological control of cotton diseases - College Station, TX. Two different potent antibiotics were isolated and identified from the bacterium Pseudomonas fluorescens. One antibiotic is effective against the soreshin pathogen of cotton (Rhizoctonia solani) and the other is highly toxic to Pythium species which cause damping off. Both antibiotics are toxic to other pathogens such as Verticillium wilt. P. fluorescens appears to proliferate in the rhizosphere of cotton roots without causing damage to the plants. Seed treatment with the live organisms or purified antibiotics, has given excellent control of seedling diseases. P. fluorescens appears promising as a biocontrol agent.

#### Improved Cultural Practices:

Early irrigation cut-off, plus chemical termination aids in control of pink bollworms in the Southwest - Phoenix, AZ. An early final irrigation on August 10 reduced the population of overwintering pink bollworms 92% and should reduce emergence of pink bollworm moths the following spring. This delays the build-up of moths to economically serious levels during the summer. The August 10 final irrigation, compared to the average producer practice of a final irrigation on September 7, reduced lint yield by about 200 lbs. However, a final irrigation on August 21, plus treatment with growth regulators to stop fruiting, gave the benefits of an August 10 cut-off for pink bollworm control with only about 100 lbs. less yield than a September 7 cut-off.

Short season cotton production system appears promising - Shafter, CA. The use of early maturing pest resistant varieties, narrow row planting patterns, reduced nitrogen, earlier cut-off of irrigation water, and application of chemical growth regulators for reducing plant size and stimulating earlier termination of growth appear very promising as components of a total production system for managing insects and reducing cotton production costs. Additional research is planned to identify optimal levels of each component for profitable production. It appears that somewhat different systems will be required for different areas within the irrigated West.

Cotton moduling affects seed quality - Shafter, CA. Storage of seed cotton in modules until it can be ginned is becoming an increasingly common practice. Seed cotton was harvested from the same field at different seed moisture contents. If before storage seed moisture was 8.8% or less, very little loss of seed germinability occurred during

storage. If before storage seed moisture exceeded 13%, however, there was a severe loss in germination percentage approximating 75%. Treatment with propionic acid through the picker reduced loss of germination from 76% to 16%.

Growth regulators increase harvesting efficiency and decrease insects - Stoneville, MS. Growth regulators were used to manipulate plant growth and development for more efficient harvest and elimination of late season feeding sites for insect pests. PIX<sup>(R)</sup>, a growth regulator, reduced plant height by 30% and permitted stripper harvest 21 days earlier than the control. Combinations of the growth regulators TD-1123 and Maintain reduced insect feeding sites by 85% and bollworm eggs and larvae by 64%.

Improved seed treatment methods reduce pollution - Lubbock, TX. Wettable powders and liquid formulations of fungicides applied to cotton planting seed, give similar stands at comparable rates of active ingredients. However, flowable and other liquid suspensions are easier to mix and apply and adhere more tenaciously to the seed coat than wetttable powders. This significantly reduces dusting of fungicides from the seed during handling.

COTTON NONCOMMERCIAL GERMPLASM RELEASED 1978

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
Aub Fg-16, Aub Fg-56, Aub Fg-149, Aub Fg-201, Aub Fg-213, Aub Fg-277, Aub Fg-310, Aub Fg-165	SEA-AR and Alabama AES, Auburn, AL	Frego-bract trait backcrossed into 8 varieties adapted to the Southeast and Delta. This trait is associated with boll weevil nonpreference and resistance to boll rot.
Aub Sm-16, Aub Sm-56, Aub Sm-149, Aub Sm-201, Aub Sm-213, Aub Sm-277, Aub Sm-310, Aub Sm-165	SEA-AR and Alabama AES, Auburn, AL	Smooth leaf trait backcrossed into 8 varieties adapted to the Southeast and Delta. This trait suppresses oviposition of bollworms and budworms.
Aub Ne-16, Aub Ne-56, Aub Ne-149, Aub Ne-165, Aub Ne-201, Aub Ne-213, Aub Ne-277, Aub Ne-310	SEA-AR and Alabama AES, Auburn, AL	Nectariless trait backcrossed into 8 varieties adapted to the Southeast and Delta. This trait suppresses certain pest insects, particularly Lygus and pink bollworm.
Aub Okra-16, Aub Okra-56, Aub Okra-149, Aub Okra-165, Aub Okra-201, Aub Okra-213, Aub Okra-277, Aub Okra-310	SEA-AR and Alabama AES, Auburn, AL	Okra leaf trait backcrossed into 8 varieties adapted to the Southeast and Delta. Okra leaf is associated with earlier maturity, whitefly nonpreference, and reduced boll rot.
Auburn 566 RNR, Auburn 612 RNR, Auburn 632 RNR	SEA-AR and Alabama AES, Auburn, AL	Very high root-knot nematode and Fusarium wilt resistance backcrossed in varieties adapted to the Southeast.

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
JPM strains - 81 lines	SEA-AR, Mississippi State, MS and Mississippi Agricultural and Forestry Experiment Station.	Diverse pool of germplasm derived from 54 <u>G. hirsutum</u> wild race accessions. Several of the strains show reduced boll weevil oviposition. Others show resistance and tolerance to <u>Cercospora</u> <u>gossypina</u> and <u>Verticillium</u> wilt. All strains flower and mature fruit in the Cotton Belt.
Pee Dee 8619	SEA-AR, Florence, SC, and South Carolina AES, Clemson University, Clemson, SC.	High fiber strength combined with high yield. Tolerant to bollworms and budworms.
Pee Dee 695 and Pee Dee 875	SEA-AR, Florence, SC, and South Carolina AES, Clemson University, Clemson, SC.	Tolerant to bollworms and budworms.

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National Research Program 20070

BREEDING AND PRODUCTION - TOBACCO

This National Research Program involves research on the following:  
(1) host resistance and biological control of diseases and insects;  
(2) nonpersistent growth regulators to reduce chemical residues in tobacco leaf; (3) genetics, cultural, and curing methods to modify cured leaf to improve consumer safety, and (4) chemical and biological evaluation of tobacco leaf and smoke for the purpose of identifying levels of constituents that should be reduced or removed because they may have health implications.

NPS Contact: E. L. Moore

Technological Objective 1.

New genetic stocks of tobacco and improved cultural, harvesting, curing, and management practices that reduce undesirable constituents and maximize quality attributes, including physical and chemical characteristics that enhance consumer use and safety.

Research Locations:

7702 Tifton, Georgia  
7809 Lexington, Kentucky  
1108 Beltsville, Maryland (Tobacco Laboratory)  
1109 Beltsville, Maryland (Plant Growth & Regulators Laboratory)  
7803 Oxford, North Carolina  
7802 Raleigh, North Carolina  
7805 Greeneville, Tennessee

Selected Examples of Recent Progress:

Extraction of natural products from certain fungi for testing as plant growth modifiers in research to discover new sucker control chemicals - Tifton, GA. A metabolite demonstrating plant growth regulating activity was isolated from the fungus Aspergillus niger found growing on leaves in a citrus orchard in Orlando, Florida in March 1978. The fungus yielded the new metabolite to which the name 'orlandin' is given. Orlandin inhibited the growth of wheat coleoptile sections at levels as low as  $10^{-5}$  M in bioassays. It was not toxic to chicks and therefore represents a new, non-toxic, natural product exhibiting plant growth inhibiting properties. Its exhibited properties make orlandin a candidate in further research to discover new chemical growth regulators for use on tobacco.

Reduce chemical residues through use of natural plant growth regulators - Beltsville, MD. Control of sucker growth on field-grown tobacco was achieved using the water-soluble fraction of plant growth inhibitors found in Ailanthus altissima. This inhibitor has been partially characterized as a derivative of ailanthone. In addition, camptothecin from

Camptotheca acuminata (95%) formulated with wettable powder surfactants controlled sucker growth on tobacco for short periods. Camptothecin at 4000 ppm applied to greenhouse-grown tobacco resulted in 71 percent control with one surfactant and 66 percent control with another after 1 week. On field-grown Hicks, 4000 ppm camptothecin resulted in 51 percent control with one surfactant and 67 percent control with another after 2 weeks. Camptothecin at 2000 ppm was not effective. These type formulations were considerably better than any previously evaluated.

Directed tobacco sucker control sprays to decrease residues - Raleigh, NC. A spray rig assembly was adapted to a high-clearance sprayer that directed the spray solution toward the stalk and downward. The spray solution wetted only one-third of the upper surfaces of the uppermost leaves while thoroughly wetting the stem and leaf axils. The technique improved control with fatty alcohols. When used with maleic hydrazide (MH), its use reduced residues without impairing control. In addition, it was found that an application of fatty alcohols following the MH treatment improved control. The complete system will reduce chemical residues, especially of MH, and still offer the grower good sucker control.

Test chemical, CGA 41065, continues to perform well in regional sucker control tests - MD, VA, NC, SC, GA, FL, TN, and KY. The N-benzylidinitro-aniline coded CGA 41065 continues to effectively control tobacco sucker growth on all major tobacco types in the ad hoc Regional Tobacco Growth Regulator tests. Efforts are continuing to have residue levels determined and other smoking and health-related aspects evaluated in order for this chemical to be utilized in agriculture. Participants conducting field evaluations have tobacco samples available which have been treated with CGA 41065, as well as appropriate check samples, so such an evaluation program can be initiated.

Breeding material resistant to budworms and hornworms - Tifton, GA and Oxford, NC. Development of budworm and hornworm resistant cultivars is an alternative to chemical means of controlling budworms and hornworms. From more than 400 lines of tobacco plants evaluated under field conditions with moderate infestation of budworm and heavy infestation of hornworm, several lines showed various degrees of resistance to budworm, and for the 2nd successive year an outstanding breeding line (progeny of dihaploids) showed high levels of resistance to the hornworm. A mutation is suspected since neither parent of I-35 has shown resistance to the hornworm. Cultivars resistant to the budworm and hornworm would reduce the need for field applications of insecticides by 75 percent.

Develop protein extraction techniques that are compatible with the HLC method of curing burley tobacco - Lexington, KY. A simplified, high-yield crystallization procedure for extracting Fraction I protein from homogenized tobacco has been developed. This procedure should be adaptable to large scale operation. Several factors affect the efficiency of protein removal and the final protein content of the cured tobacco. Grinding with one pass through the deflaker yielded about 90 percent as much solubilized protein as two passes. Additional grinding did not increase the yield of protein,

but tended to destroy the fiber and cause difficulties in the dewatering process. The protein rapidly became insoluble with only about 10 percent of the protein being soluble after 20 hours of incubation. The more mature the leaves, the smaller the proportion of soluble to insoluble protein and the more rapidly the protein became insoluble after grinding. Although about 60 percent of the total protein could be removed from leaves at conventional harvest time, a much larger proportion of protein was hydrolyzed during incubation of the control than during incubation of the deproteinized tobacco. The cured control was about 25 percent higher in protein. A 600 lb. sample of deproteinized HLC tobacco and a 600 lb. sample of standard HLC tobacco was processed during the 1978 season for smoke chemistry and long-term bioassay evaluation.

Optimizing yield and Purity of Leaf Proteins Extracted From Tobacco During Homogenized Leaf Curing (HLC) - Oxford, NC. Plant variety and time of harvest had greatest impact on yield and purity of soluble proteins (Fraction I and Fraction II) in bright tobacco. Extractable protein reached a maximum level of 16 percent (dry weight basis) at flowering time and then declined one-half each succeeding week. Protein purity in precipitate varied from 50 to 90 percent depending on tobacco genotype. To a lesser extent, yield and purity were improved by first filtering juice through a cartridge filter and amborsorb packed columns to clarify it, then coagulation of chlorophyll at 40°C followed by precipitation of protein at 65°C.

New method of measuring protein content of tobacco - Oxford, NC. A high performance liquid chromatographic (HPLC) technique was developed to measure protein content in tobacco leaf extracts. The new method is rapid, precise, requires very small samples, and separates Fraction I from Fraction II protein components. This breakthrough enables the extraction and fractionation steps in tobacco protein recovery to be accurately monitored. Because the molecular stability of soluble leaf protein is highly sensitive to cultural and processing conditions, it is extremely important to be able to determine the effects of these variables on protein extractability. The removal of protein from tobacco leaves has a two-fold purpose: preparation of a safer tobacco for smoking and recovery of an edible protein byproduct.

Method of producing HLC in sheet form Oxford, NC. Manufacture of tobacco products from HLC will be facilitated if it can be processed in suitable sheet form. A major characteristic of good sheet formation as HLC is dried is ability of tobacco fiber to bind to itself instead of to the dryer surfaces. A survey of 31 tobacco genotypes revealed that six were excellent; nine, good; eight, fair; and eight, poor, sheet formers. Out of three guar gums tested as binders, one substantially improved the flake properties of HLC material. The form in which HLC is dried may influence cost of production and economic acceptability without regard for improved health-related aspects of consumer use.

Plant precursors of phenols in tobacco smoke - Lexington, KY. Investigations were completed for the development of high-pressure liquid chromatographic (HPLC) methods for the analysis of nine phenolic phenylpropanoids in tobacco. These compounds are considered as health-related because they serve as probable precursors of simple phenols in tobacco smoke. The HPLC methods permitted the rapid analysis of nanogram to microgram amounts of lignin precursors related to hydroxycinnamic acids, aldehydes, and alcohols. The new methods also made it possible to isolate chromatographically-pure compounds by collection of chromatographic fractions of tobacco extracts. The isolates could be characterized by mass spectral analysis. Preliminary analyses of tobacco midvein and stalk samples indicated that coniferyl and sinapyl alcohols were major phenylpropanoids in hot water extracts. It was determined that these compounds were probably bound to tobacco cell constituents (lignin or carbohydrate) by covalent bond linkages that were cleaved by hydrolysis with hot water. Sinapaldehyde was also determined to be a minor constituent of methanol and hot water extracts of tobacco. Several samples that were produced by new production practices were analyzed to determine the effects of these practices on concentrations of phenolic phenylpropanoids.

The mechanism of plant tumor induction by chemicals in a short term bioassay system - Lexington, KY. Naturally-occurring cytokinins (cell division factors) influence the development of plant tumors, although the nature of their function in this kind of cellular differentiation is not understood. A reverse-phase, high pressure liquid chromatographic (HPLC) method was developed for the separation and analysis of several authentic individual cytokinins and their geometrical isomers. The method, which utilizes a linear solvent gradient permits the isolation of known and unknown cytokinins which can then be used for determinations of biological activity and chemical characterization studies.

Genetics and breeding lead to a safer tobacco - Beltsville, MD. Nicotine, tar, and other chemical constituents are known to differ widely among plants varying in genetic makeup, culture and, and disease infection. Screening 1,100 tobacco introductions, development of disease resistant breeding lines such as those having monogenic resistance to Race 1 of the wildfire bacterium, polygenic resistance to brown spot, resistance to frogeye leafspot, and immunity to etch virus, will contribute to this goal and lead to the development of a safe tobacco. Disease resistant plants not only reduce the need for pesticides, but also modify the chemical composition of the leaf. Diseases have been shown to adversely affect content of health-related constituents in cured leaf.

Host resistance to control diseases in several tobacco types - Beltsville, MD. Tobacco breeding lines were developed with stabilized monogenic dominant resistance to Race 1 of the wildfire bacterium, a major pathogen of cigar tobacco. Stabilized flue-cured breeding lines were advanced having polygenic resistance to brown spot. Frogeye leafspot resistant breeding lines were obtained having all resistant plants, indicating stabilization of a factor or chromosome transferred from Nicotiana repanda to tobacco. Both brown spot and frogeye leafspot have severe adverse effects on health-related constituents.

Reduction of tar to nicotine ratios - Oxford, NC. Tobacco genotype (varieties) was found to influence tar content of cigarette smoke to a greater extent than tobacco produced at different locations (four locations). Tar content expressed as mg/cig ranged from a low of 23.41 (Variety Speight G-28) to a high of 31.55 (Variety NC 78). Location variation ranged only from 26.7 to 27.5 mg/cig. Tar to nicotine ratios ranged from 5.9 (Variety Speight G-15) to 8.8 (Variety McNair 1040). While the optimum ratio is unknown, it is assumed lower values are desirable.

Nicotine levels in two families of flue-cured breeding lines - Oxford, NC. The lines of each family had a common genetic background. In the NC 95 (nicotine level 2.80%), family progenies were identified with nicotine levels as follows: 0.36, 1.14, 1.64, 2.01, 2.75, 3.26, and 3.94 percent. In the SC 58 (nicotine level 4.54%), family progenies were identified with nicotine levels as follows: 0.41, 1.57, 2.34, 3.17, 4.00, and 4.49 percent. It is interesting that seven nicotine levels were identified in the NC 95 family and two exceeded the level of the high nicotine parent, whereas in the SC 58 family, six levels were identified and none exceeded the level of the high nicotine parent. Yields and quality of the progenies met acceptable standards. Thus, nicotine levels can be generated to meet a broad range of needs.

Chemical analysis of tobacco leaf by near infrared spectrophotometry - Oxford, NC. Near-infrared reflectance spectra of ground samples can be used to simultaneously predict the levels of total polyphenols, total alkaloids, reducing sugars, total nitrogen, nicotine and nornicotine in tobacco leaf. Calibration correlations suggest that the levels of another ten chemical constituents, including tar, can be predicted simultaneously. This technique could greatly expedite the tobacco safety research.

New technique for producing tobacco haploids - Oxford, NC. Genetically useful haploid plants, derived by a complicated anther-culture method, can now be obtained from seed by the simple expedient of crossing Nicotiana tabacum with N. africana and selecting surviving haploids from among the numerous lethal hybrid seedlings.

Biological control of foliar plant diseases by antagonism - Oxford, NC. In field applications for tobacco Alternaria leafspot and peanut Cercospora leafspot control, aqueous mixtures of Bacillus thuringiensis (Bt) ranging from 1-30 billion IU's per acre were sprayed following a fungicide time schedule known to provide effective control. Disease control up to 50 percent was obtained. The results proved that field applications of Bt had considerable potential for disease control.

Infection mechanisms of Alternaria conidia and interactions with leaf surface bacteria - Oxford, NC. The scanning electron microscope (SEM) was used to observe the initiation of disease by pathogenic Alternaria conidia on tobacco leaf surfaces. Conidial germination and growth were variable. Frequently several cells of a conidium germinated, and occasionally these germ tubes would form branches. Penetration points were found

associated either with an appressorium or a modified appressorium and a coiled germ tube. Penetration was through the cuticle. When an appressorium was displaced during SEM preparation procedures, a penetration pore with an associated raised area of the leaf surface, resembling a donut, was observed. An occasional appressorium was formed directly on a guard cell, sunken areas surrounding points of penetration probably resulted from the collapse of cells internally. Some germ tubes grew tightly appressed to trichomes, but penetration of trichomes was not observed. Preliminary observations were made of interactions on the leaf surface between fungal spores and antagonistic bacteria which may control disease development. The primary challenge emerging from these studies is that the future of biological control of foliar diseases is dependent upon the development of formulations which will favor the survival of bioagents following application and at the same time not promote pathogen growth.

#### EXTRAMURAL

Growth and curing factors affecting tar levels - Lexington, KY. Tobacco leaf and tobacco tissue cellular component contribution to particulate matter were investigated. Leaves from stunted plants had a higher than normal ratio of membrane material and tar level. Lower tar levels were obtained in lower-stalk leaves and in leaves cured in an atmosphere containing elevated oxygen levels and/or ethylene.

Leaf protein in tobacco - Lexington, KY. Enzyme activity revealed that in spite of greater Fraction I protein in burley tobacco leaves, activity was higher in flue-cured tobacco, indicating a more active protein.

Terpenoid fractions in tobacco - Lexington, KY. The terpenoid fraction in tobacco is thought to be health related. Therefore, it is important that methods be devised to determine the fraction. A method has been devised to determine the terpenoid fraction in tobacco.

Modification of the chemical composition of burley tobacco by virus infection - Lexington, KY. Tobacco vein mottling virus caused an increase in protein N, decrease in total alkaloids, and a significant increase in sterol content. However, tobacco etch virus did not increase the sterol content.

Protein content of homogenized leaf cured tobacco (HLC) - Lexington, KY. A comparison of mature burley tobacco samples revealed that standard HLC tobacco contained 21 percent more protein and 11 percent more free amino acids than deproteinized HLC tobacco.

Effect of post harvest processing on nitrosonornicotine (NNN) levels in tobacco - Lexington, KY. NNN levels in tobacco leaf are increased during curing. Bulk curing of burley tobacco increased NNN levels above stalk cured. Bulk cured burley tobacco had increased levels of oxides of nitrogen in the smoke compared to that of conventionally stalk cured.

Extraction of Fraction I (F-1-P) and Fraction II (F-2-P) proteins serves dual purpose - Baltimore and Beltsville, MD. More than one pound each of pure F-1-P and F-2-P were extracted from green tobacco leaf tissue for animal feeding and pyrolytic studies. Amino acid composition of F-1-P and F-2-P was quite similar and rat feeding studies showed them to be similar in nutritional value and about equal to casein from milk. Pyrolytic studies indicated that upon combustion the proteins yield significant amounts of quinoline, HCN, and oxides of nitrogen, all highly undesirable in tobacco smoke. Thus, removal of the proteins has the potential of making tobacco safer for consumers and at the same time yielding a byproduct useful as food or feed.

Preliminary bioassay data showed maleic hydrazide (MH) has no adverse affects - Beltsville, MD. Both short term and long term bioassay of cigarette smoke condensate from experimental tobacco showed no significant differences in biological activities among hand suckered, field treated with MH, field treated with fatty alcohol, and leaf spiked with 1,000 ppm MH. The sebaceous gland suppression method was used for short term tests and mouse skin painting with two dosage levels up to 52 weeks was used for long term tests. A second study with longer exposure will be conducted to confirm this finding. This result is very important as MH is widely used as a suckering agent for tobacco production, and questions have been raised relating to the possible carcinogenicity of this compound or its combustion products.

Search for host resistance to viruses - Madison, WI. Tomato spotted wilt virus (TSWV), a serious tobacco disease in many parts of the world, has occurred sparsely in the U.S. Chemical control of the vector, Thrips spp, is an effective method of control. Screening of Nicotiana spp and Nicotiana hybrids revealed no host resistance to the virus among those tested, including N. alata, which had been reported to be resistant in Poland. Derivatives of the hybrid N. tabacum x N. benavidesii were screened for resistance to potato virus Y (PVY) and several resistant selections were obtained.

## Technological Objective 2

New and improved genetic populations, breeding lines and varieties of tobacco that combine high yield potentials, better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, curing, harvesting, and handling to minimize production losses, and use scarce resources efficiently.

### Research Locations

7702 Tifton, Georgia  
7809 Lexington, Kentucky  
1108 Beltsville, Maryland (Tobacco Laboratory)  
1109 Beltsville, Maryland (Plant Growth and Regulators Laboratory)  
7803 Oxford, North Carolina  
7802 Raleigh, North Carolina  
7805 Greeneville, Tennessee

### Selected Examples of Recent Progress:

More effective and safer sucker control agents - Tifton, GA. The application of sucker control chemicals continued to prove effective in controlling sucker growth on field-grown flue-cured tobacco. Two applications of fatty alcohol (FA) followed by maleic hydrazide (MH) increased sucker control from 57 percent on the hand suckered check to 99 percent on the FA/FA/MH-treated plants, and reduced sucker green weight from 5,500 lbs down to 17 lbs per 7000 plants (acre) on the same treatments. Furthermore, the chemical treatment reduced leaf breakage and loss from 1,500 leaves down to zero and increased the yield of cured leaf about 400 lbs over the hand suckered check.

Improved tobacco seedlings and uniformity of growth in the field - Tifton, GA. Clipping the leaves on the larger tobacco seedlings twice at 4-6 day intervals with a modified rotary mower just prior to transplanting reduced shading effect and increased light penetration to the smaller plants, reduced stem length variance, and increased the percentage of plants suitable for transplanting at one pulling by more than 50 percent, all of which should improve progress toward mechanization and crop uniformity.

Improved efficiency in anther culture to produce dihaploid plants - Oxford, NC. In an earlier procedure, the haploid plantlet mass germinating from an anther was harvested and treated with the chromosome-doubling chemical, colchicine, when the largest plantlets were 2 to 3 cm tall. Thus, many small plantlets in the mass were lost. In the new procedure the germinated anther is planted in soil where colchicine-treated plantlets develop roots and are harvested individually at 3 cm in height. Repeated harvests results in a threefold increase in dihaploid plant production thereby saving time and space.

Linkages broken in dihaploids between disease resistance and reduced yields or poor quality - Oxford, NC. Results from field plot studies, conducted in 1977 and 1978, on dihaploids with various combinations of resistance or susceptibility to tobacco mosaic virus (TMV), potato virus Y (PVY), and root knot nematodes indicated the following: (a) the genes bearing the trait for PVY resistance generally were associated with the higher yielding entries, (b) TMV resistance was usually associated with lower government grades of cured leaf, thereby indicating reduced quality, and (c) root knot resistance was often associated with reduced yields and quality. Individual exceptions to these results were observed. This suggests that linkages had been broken or favorable combinations of gene modifiers had been accumulated in the exceptional individuals. The entries that showed significantly higher yields in 1977 also were high yielding in the 1978 study. Entries with unusually high or low levels of alkaloids or reducing sugars were observed. This finding supports earlier observations and suggests that the haploid/diploid method may be useful in inducing rapid changes in levels of chemical constituents.

Lethal responses to potato virus Y (PVY) in root knot resistant tobacco to PVY - Oxford, NC. PVY inoculations of dihaploid lines with combinations of resistance or susceptibility to PVY and root knot confirmed that lines with resistance to root knot and susceptibility to PVY are killed when inoculated with a necrotic strain of potato virus Y. However, lines with resistance to both diseases are not killed by the necrotic strain, although virus symptoms develop in young plants. This finding provides the first evidence that it is possible to overcome the lethal response of root knot resistant lines to necrotic PVY by adding PVY resistance to root knot resistant lines of tobacco.

Alternatives to maleic hydrazide (MH) for sucker control are costly - Raleigh, NC. Field research in 1978 demonstrated that tobacco produced without the use of MH will increase costs by at least \$150 per acre. Fatty alcohols, the alternative suckering agents available, were applied three times. Because they do not control suckers completely, the time involved to hand sucker ahead of each of the four harvests required was recorded. This was done so that no suckers would appear in mechanically-harvested leaf. Increased costs came from the hand suckering and the loss in yield. Growers should not misuse MH because, if unavailable, the alternatives will be costly.

Increased nitrogen fertilization makes sucker control more difficult - Raleigh, NC. Continued study with MH control of suckers on plants grown with either normal or normal plus 20 lb/A nitrogen. Although control was easier during 1978 than in 1977, the added nitrogen required more MH to obtain season-long perfect control because of increased sucker growth.

Burley tobacco breeding line, Greeneville 107, released in cooperation with the Tennessee Agricultural Experiment Station - Greeneville, TN.

Greeneville 107 represents a significant accomplishment in the combination into one source of resistance to four virus diseases: potato virus Y (PVY), tobacco vein mottling virus (TVMY), tobacco etch virus (TEV), and tobacco mosaic virus (TMV), with resistance to three fungus diseases (blackshank, black root rot, and Fusarium wilt) and a bacterial disease (wildfire). All of these diseases are highly destructive on burley tobacco with respect to yield and quality. Greeneville 107 is comparable to Burley 49, a low yielding variety, but under certain critical disease situations it could be used as a variety. Its greatest potential is for use in the development of multi-disease resistant varieties to circumvent the buildup of pesticide residues in burley tobacco.

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National Research Program 20080

BREEDING AND PRODUCTION - SOYBEANS, PEANUTS, AND OTHER OILSEED CROPS

This National Research Program involves research to improve agricultural production efficiency by developing new and improved plant genetic resources and cultural and management practices for soybeans, peanuts, sunflower, flax, safflower, and guar. Plant geneticists, agronomists, plant pathologists, plant physiologists, microbiologists, chemists, entomologists, and soil scientists (both Federal and State) work in a team approach to evaluate and improve oilseeds and improve cultural methods.

NPS Contact: R. C. Leffel

Technological Objective.

New and improved genetic populations, breeding lines, and varieties of oilseed crops that combine improved yield potentials and favored quality characters, including reduced contents of undesirable constituents, with better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, harvesting, and handling.

Research Locations:

5206	Davis, California
7602	Gainesville, Florida
7702	Tifton, Georgia
3311	Urbana, Illinois
3302	West Lafayette, Indiana
3408	Ames, Iowa
1110	Beltsville, Maryland
1109	Beltsville, Maryland
7402	Stoneville, Mississippi
3402	Columbia, Missouri
7802	Raleigh, North Carolina
3602	Fargo, North Dakota
3307	Wooster, Ohio
7317	Stillwater, Oklahoma
3608	Brookings, South Dakota
7315	Bushland, Texas
7314	Vernon, Texas
7812	Suffolk, Virginia

Selected Examples of Recent Progress:

Soybeans:

Cyst and root-knot nematode resistance combined with high yield - Gainesville, FL. Increased resistance to nematodes has been incorporated into high yielding soybean breeding lines adapted to the Gulf Coast

production area using standard breeding techniques. After further evaluation to identify lines with the best overall performance in the Southern Region, one or more will be released for commercial production. Farmers who grow these new cultivars will subject their crops to fewer production hazards and will prevent further buildup of these particular nematode pests in their production fields without the use of expensive pesticides.

Technique developed for screening soybeans for field resistance to Phomopsis seed infection - Urbana, IL. Soybeans are placed under an irrigation system at the pod-fill stage of growth and then maintained under a moist environment until mature. This system provides a high moisture environment for severe Phomopsis seed infection. Soybean varieties and soybean plant introductions can be successfully screened for field resistance by using this system since a moist environment is required for maximum disease development. By using this system, there has been a reduction in research plot costs since it is no longer necessary to establish numerous plot locations in order to obtain an environment suitable for severe disease development.

Evaluated yield losses in soybeans caused by Septoris brown spot - Urbana, IL. In 1977 brown spot caused yield reduction of 12 percent in naturally infected soybeans and 12 - 13.7 percent in soybeans artificially inoculated at various growth stages. In 1978 yield reduction was 8 percent in naturally infected soybeans and 8.7 - 30 percent in artificially inoculated soybeans. Reliable estimation of potential yield losses is very important in improving soybean production. Two basic models have been developed which provide best estimates of yield loss caused by brown spot.

Developed methods to evaluate soybeans for disease resistance - Urbana, IL. Efficient inoculation procedures suitable for large scale field application and rapid and reliable methods for measuring soybean reaction to brown spot were developed. These methods are used to evaluate a large number of soybean germplasms annually for sources of disease resistance.

Disease resistant soybean released - West Lafayette, IN, in cooperation with Indiana, Illinois, and Michigan Agricultural Experiment Stations. A destructive disease of soybeans, phytophthora root rot is caused by a fungus often found in heavy, poorly drained soils of the Midwest. The new variety Wells II is resistant to 7 of the 9 known races of the disease. The main advantage of Wells II to Wells is its resistance to 5 additional races of phytophthora root rot. Like Wells, it has very good yield and excellent lodging resistance.

Uniform tests for Northern States provide varieties - West Lafayette, IN, and cooperating agencies. The Uniform Tests for Northern States provided the data for the release of 9 new varieties: 'Wells II' and 'Miles' (described elsewhere in this report); 'McCall', 'Cumberland', and 'Sloan' for superior yields; 'Hodgson 78', 'Oakland', and 'Vickery' for resistance to phytophthora root rot; and 'Vinton' as a large-seeded specialty variety.

Essential features of the primary structure of a glycinen subunit determined - West Lafayette, IN. The subunits of the 11S storage protein from a soybean cultivar have been purified and characterized. Six polypeptides with acidic

isoelectric points, as well as 4 basic ones, have been identified as part of the glycinen complex. Amino acid analysis of the purified subunits showed that certain ones contained 3 - 6 times more methionine and cystine than the others. This is the necessary first step in identifying structural genes for glycinen.

Brown stem rot resistant lines released - Ames, IA, in cooperation with Iowa and Puerto Rico Agricultural Experiment Stations. Two brown stem rot (BSR) resistant lines were released as germplasm: A74-101035 (Maturity Group I) and A75-332035 (Maturity Group III), released as A3 and A4, respectively. BSR resistant line A75-302005, in Regional Uniform Test III for the second year and in multiple location tests in infested land in Iowa for the third year, was found significantly superior in BSR land to all soybean varieties, old or new. Breeder's seed of A75-302005 was grown during the year. Another advancing BSR resistant line, A76-304019, averaged 10 percent higher yields than A75-302005 in the above tests in infested lands.

Variety with specific and general resistance to phytophthora root rot released - Ames, IA, and Iowa, Ohio, Puerto Rico, and Indiana Agricultural Experiment Stations. 'Vickery' cultivar was released for commercial production where phytophthora rot is a major problem. It is the first phytophthora resistant variety with both specific and general resistance. It was developed for multiple race resistance and field tolerance under Ohio conditions. Additional races of Phytophthora megasperma var. sojae were discovered in Iowa in 1978. The Pms races found in Iowa in 1978 were 3, 6, and an unidentified new race.

New soybean cultivar released - Beltsville, MD, in cooperation with Maryland Agricultural Experiment Station. A new soybean cultivar 'Miles' was released in cooperation with the Maryland Agricultural Experiment Station. Seed yields of 'Miles' were 11 percent above 'Kent' in 17 regional tests grown in the Mid-Atlantic area in 1975-76. 'Miles' has better seed quality and greater resistance to pod and stem blight, purple stain, and bacterial blight than 'Kent' and has greater resistance to shattering.

Toxins in Rhizoctonia interfere with nodulation and nitrogen fixation in the soybean - Beltsville, MD. The soilborne fungus Rhizoctonia solani, the cause of damping-off and root rot of soybeans, was found to release toxic compounds which affect nodulation and nitrogen fixation. These toxins were isolated and characterized as meta-hydroxyphenylacetic and meta-methoxyphenylacetic acids. This finding may also facilitate the development of a screening method to identify soybeans with root rot resistance.

Budblight disease reduces nitrogen fixation and seed yield in soybean - Beltsville, MD. The severity of budblight of soybean caused by tobacco ringspot virus was found to vary with the time of infection in the growth cycle. Early plant infection which originates with seedborne virus or from leaf infection reduced seed yield 90 percent or more. Late plant infection, i.e., just before flowering, interferes with yield also but to a lesser degree.

High protein combined with disease resistance and high yield - Stoneville, MS. The breeding line D76-8070, which is resistant to bacterial pustule, phytophthora rot, soybean mosaic virus, and the root-knot nematode Meloidogyne incognita, produced a seed yield within the range of experimental error of Forrest and had an average protein content of 49.8 percent as compared with 40.3 percent for Forrest.

Inheritance of resistance to leaf-feeding insects determined- Stoneville MS. F<sub>2</sub> populations from second cycle crosses were grown in a large field cage and infested with soybean looper in 1977. F<sub>3</sub> progenies were grown in 1978 and infested in a similar manner. All progeny of F<sub>2</sub> plants rated resistant were uniformly resistant. Progeny from F<sub>2</sub> plants having somewhat more leaf feeding segregated for reaction or were moderately susceptible. Two or three major genes, recessive in nature, appear to give resistance to feeding by soybean looper.

Uniform tests for Southern States provide five new varieties - Stoneville, MS, and cooperating agencies. The Uniform Tests for Southern States provided the data for the release of five new varieties: 'Ware' and 'Bay' have excellent seed quality and high yields, and 'Dowling', 'Gail', and 'Alamo' are high yielding and adapted to the Gulf Coast area, High Plains of Texas, and Lower Rio Grande Valley of Texas, respectively.

Incorporation of fatty acids by intact developing soybean cotyledons - Raleigh, NC. The ability of intact developing plant tissues to incorporate and utilize long chain fatty acid substrates in fatty acid and glycerolipid biosynthesis was not demonstrated prior to this investigation. This technique was applied to determine the precursor of linolenic acid and to define the nature of lipid metabolism in developing soybean seeds. Results indicated that oleic acid, but not palmitic acid nor stearic acid was the precursor of polyunsaturated acids in soybeans. This result has an important bearing on genetic manipulation of fatty acid composition of oil.

Effect of altered source-sink relations on carbon metabolism in soybean root tissues - Raleigh, NC. Increased supplies of photosynthate to root tissues during the reproductive stage of soybean growth is thought to enhance nitrogen fixation. Reduced pod set allows more photosynthate translocation to root tissues; however, this investigation demonstrated that root tissues on plants with reduced pod set stored excess photosynthate in starch and oil instead of using the substrates in respiratory metabolism.

Improvement of soybean oil quality by reducing linolenic acid - Raleigh, NC. Genetic selection for improved soybean oil quality has reduced linolenic acid in soybean oil from 8 percent to 4 percent in the fifth cycle of recurrent selection. It is estimated that further reduction of linolenic acid to 3 percent would eliminate the cost of chemical processing to protect soybean oil quality and save the processing industry approximately 4.5 to 5 cents per pound of refined soybean oil produced.

Recurrent selection procedures increase selection efficiency in soybean germplasm development - Raleigh, NC. Mass selection among male-sterile plants followed by within half-sib family selection on male-fertile plants increased seed oil concentration at the rate of 0.4 percent per cycle. Seed yield did not change so that concentration and total production of oil per unit area was increased. Both phases of a selection cycle are accomplished in a single year and both contribute to progress from selection. The procedure maximizes selection gain per year.

#### Peanuts:

Peanut genotypes resistant to *Aspergillus flavus* colonization - Tifton, GA. Several lines from crosses that were developed to breed for resistance to toxic strains of *A. flavus* are in the advanced stage of selection for possible release. One line, A7109, is currently receiving additional critical chemical, organoleptic, and agronomic evaluation for release next season. Its agronomic performance is equal to Florunner, plus it has considerable *A. flavus* resistance. Every segment of the peanut industry considers the aflatoxin problem related to this fungus to be the major problem they are facing in the future. This importance is of great concern since aflatoxin is one of the most carcinogenic natural agents known. Its occurrence in an important food crop like peanuts creates a major human health concern.

Germplasm release for specific characteristics - Tifton, GA, in cooperation with Florida and Georgia Experiment Stations. 'Jenkins Jumbo' was released as a parental line, exhibiting very large seed, thick hull, and excellent stability of oil.

Wild species a source of disease resistance - Stillwater, OK. Advanced crosses were made between cultivated peanuts and selected complex hybrids involving cultivated and wild peanut genomes. Hybrids were achieved between cultivated peanuts and selected fertile colchiploid species developed from wild species carrying leafspot resistance factors. Test crosses were made between cultivated peanuts and recent wild peanut accessions from South America to establish cross-compatibility relationships. A high level of resistance to two virulent isolates of *Cercospora arachidicola* was found in hybrids between two wild species of peanuts (*Arachis*) (HLK 410 = P.I. 338280 and GKP 10602 = P.I. 276235) in preliminary greenhouse tests.

*Cercospora* species attacking peanuts in the Southwest determined - Stillwater, OK. *Cercospora arachidicola* (the causal agent of early leaf-spot) was the predominant fungus isolated from the collections made during the season. *Cercosporidium personatum* (late leafspot) was isolated late in the summer from Spanish peanuts growing in Haskell and Hughes County, Oklahoma. No differential responses were detected in the host-parasite reactions on several peanut genotypes that were inoculated with several isolates of *Cercospora arachidicola*.

### Sunflowers:

Hybrids between commercial and wild sunflowers obtained - Davis, CA. Wild Helianthus species were grown and morphological features compared with descriptions in the Heiser monograph. Chromosome number and pollen fertility were also determined. An embryo culture technique was developed which makes crossing distantly related species easier. Crosses were successful when pollen from domestic lines were placed on wild species flowers. F<sub>1</sub> plants were successfully grown to maturity from seven wild species (H. argophyllis, H. bolanderi, H. petiolaris, H. hirsutus, H. giganteus, H. maximiliani, and H. grosseratus pollinated with either P-21 or Ha89 pollen). These crosses have been previously reported: A cross not previously reported and obtained was H. angustifolius x H. annuus. The hybrids were confirmed by morphological comparisons of the two parental types especially leaf length, width, or the ratio of length to width.

Cotton defoliating isolates of Verticillium incite wilt of sunflower - Beltsville, MD. All isolates of Verticillium from infected sunflower plants in the southern Great Plains were identified as the cotton-defoliating strain of V. dahliae. Compared to isolates of V. albo-atrum from the northern Great Plains, these isolates were slightly less virulent to "susceptible" cultivars, but more virulent to "resistant" cultivars.

New source of disease resistance and other desired characteristics - Fargo, ND. Ten lines of three wild sunflower species were identified as having genes for resistance to downy mildew and rust. Backcrossing has been initiated to incorporate these genes into cultivated species. Five nonoilseed advanced experimental lines used in hybrid combinations showed significant yield and quality improvement over presently grown commercial varieties. Resistance to predation in certain sunflower inbreds by selected bird species has been confirmed. Correlation between degree of bird predation and phenolic acid content was small and nonsignificant.

Two photoperiodic responses by sunflowers - Fargo, ND. Sunflower cultivars studied under both long- and short-day regimes show two classifications: 1) those having a day-length neutral flowering response, and 2) those having a long-day-length flowering response.

Evidence for increased oleic acid content - Fargo, ND. Results of evaluating segregating F<sub>2</sub> and F<sub>3</sub> derived sunflower lines for oleic acid content indicate the presence of a dominant factor for increased oleic acid content.

Hybrids superiority greatest under stress conditions - Fargo, ND. Commercial hybrid sunflower varieties demonstrated an even greater yield advantage over open-pollinated varieties under moisture and heat stress conditions than under favorable growing conditions.

Sunflower species collection completed - Bushland, TX. The wild Helianthus collection is complete: all recognized N. American species have been collected and are being maintained at Bushland. Besides being used extensively in the insect and disease resistance screening work at Bushland, this material has been sent to eleven foreign countries and many locations in the U.S. It is being screened for a diversity of genetic characteristics needed to improve cultivated sunflower. Currently, the U.S. is negotiating a Helianthus germplasm exchange with the U.S.S.R. They need our wild germplasm to screen for Sclerotinia and Botrytis resistance and we are most interested in receiving 'Pervenets', a new variety high in oleic fatty acid.

Flax:

Lines with multiple genes for flax rust resistance developed - Fargo, ND. Pathogenicity tests with selected races of flax rust identified the M<sup>3</sup>P<sup>3</sup> gene combination in the third backcross using four<sup>3</sup> current varieties as the recurrent parent. Three lines containing the M<sup>3</sup>P<sup>3</sup> combination performed significantly better than the check varieties in the Cooperative Regional Flax Trials. Wilt resistance was equal to Lipott.

Role of enzyme in seedling tissue determined - Fargo, ND. Linolenic acid is converted to 12-oxo-cis-10,15 phytodienoic acid (12-oxo-PDA) via a 13-hydroperoxy-linolenic acid intermediate. Substrate specificity studies showed that n-3,6,9 unsaturation was an absolute requirement for the conversion of polyunsaturated fatty acids into cyclic fatty acids. The hydroperoxide-cyclizing enzyme was demonstrated in 15 of 24 plant tissues studied.

Identification of a wound hormone in plants - Fargo, ND. A product of fatty acid oxidation in plant tissue has been characterized as a wound hormone. The compound, called trans-10-ODA, is formed in response to wounding or cutting of tissues. In the 1930's, a wound hormone called traumatin was characterized as traumatic acid. Using modern methods of analysis, it has been shown that trans-10-ODA is the natural product and traumatic acid is an artifact. The identification of trans-10-ODA in a number of plant tissues is significant because it suggests that it may have a general role in the wound healing process.

Safflower:

Phytophthora root rot resistant germplasm developed - Davis, CA. 14-5 was developed from VF stp-1, and prohibits resistance to phytophthora root rot, verticillium wilt, and fusarium wilt, and striped hull seeds.

Resistance to the four known races of fusarium wilt found - Davis, CA. Twenty safflower introductions were found among the world collection to be resistant to race 4 of Fusarium oxysporum f. sp. carthami and also to the other known races. They comprise a diverse germplasm pool for development of resistant cultivars for control of Fusarium disease. A modified inoculation technique resulted in discrete differences between resistant and susceptible plants.

Multiple disease resistant germplasm developed - Beltsville, MD.

LMVFP-1 was developed from VF stp-1, and exhibits resistant to lettuce mosaic, verticillium wilt, fusarium wilt, and phytophthora root and hypocotyl rot, vigorous growth habit, and striped hull seeds.

Inheritance of resistance to lettuce mosaic determined - Beltsville, MD.

F<sub>1</sub>, F<sub>2</sub>, and BC<sub>1</sub> generations from B3 x VFR-1, and the F<sub>1</sub> and F<sub>2</sub> generations from B3 x N10, indicated resistance to systemic necrosis reaction is dominant to mosaic, also conditioned by a single dominant gene. The inheritance appears to be recessive gene epistasis.

Guar:

Guar lines with insect resistance - Vernon, TX. The cooperative midge resistance screening program was continued in 1978. Twenty-eight plant introductions and 25 advanced generation breeding lines were screened for midge resistance in the field. In three years of field screening, 7 cultivars have been identified which show low midge infestation.

Branching characteristic superior in yield - Vernon, TX. A branching variety (Kinman) and an experimental non-branching composite were compared at 3 row spacings and 2 plant populations at Chillicothe and Munday, Texas. The branching variety yielded significantly more than the non-branching composite at both locations. Significant yield differences for row-spacings and populations were detected only at the Chillicothe site.

Technological Objective 2.

New and improved cultural and management practices that increase oilseed crop yields, minimize production losses, improve quality attributes, and conserve and use scarce resources efficiently.

Research Locations:

5206	Davis, California
7602	Gainesville, Florida
3311	Urbana, Illinois
3302	West Lafayette, Indiana
3408	Ames, Iowa
1109	Beltsville, Maryland
7402	Stoneville, Mississippi
3402	Columbia, Missouri
7802	Raleigh, North Carolina
3307	Wooster, Ohio
3608	Brookings, South Dakota
7302	College Station, Texas
7314	Vernon, Texas
7812	Suffolk, Virginia

Selected Examples of Recent Progress:

Soybeans:

Diurnal variation in nodule activity is a temperature response - Urbana, IL. The reported diurnal variation in nodule activity was shown to be a temperature response rather than a light response as previously thought. Analyses of carbohydrate content of the plant tissues suggested that reserve photosynthate (primarily of shoot origin) was available to support nodule activity for as long as 72 hours in the absence of concurrent photosynthesis. This effect of temperature on nodule activity needs to be explored further for purposes of modeling physiological responses and growth of soybeans.

Roles of nitrate and fixed nitrogen - Urbana, IL.  $^{15}\text{N}$  labeling emphasized the importance of nitrate to early vegetative growth at lower nodes. The contribution of dinitrogen via  $\text{N}_2$  fixation to seed N was greatest in seed from upper regions of the canopy. The results support the conclusion that there is no justification for nitrogen fertilization of soybeans providing that there is sufficient residual nitrogen to support early canopy development. Preliminary results indicate that soybeans which are dependent on biological  $\text{N}_2$  fixation as the sole N source respire more carbon via the nodulated roots than do comparable roots of soybeans solely dependent on  $\text{NO}_3^-$ -N; the absolute magnitude is still tentative. Implications are that biological  $\text{N}_2$  fixation is more energy demanding than  $\text{NO}_3^-$  metabolism.

Changes in fatty acid composition of lipids during seed development detected - Urbana, IL. Studies have been carried out to gain a better understanding of the complex mechanisms involved in oil biosynthesis in developing soybean seeds. It has been shown that phospholipids play a very important role in the biosynthesis of the soybean oil. An understanding of the role of specific phospholipids involved in oil biosynthesis could lead to the production of a soybean oil that contains much lower amounts of linolenic acid. Linolenic acid is the major component in the soybean oil which has been implicated as the major cause of flavor problems.

Chromosome transfer in soybean nodulating bacteria detected - Beltsville, MD. Field reisolates of I-110 azi-5 rif-17 str-74 (AR) were screened for chromosome donor ability with I-110 5fu-1 nal-25 as the recipient. Putative recombinants were selected on medium containing rifampicin, streptomycin, and nalidixic acid (R+S+N) and were then screened for the unselected 5-fluorouracil and azide resistance markers by replica plating. Cotransfer of determinants for str and rif in the matings but not in the controls was unambiguous since two Azi<sup>S</sup>, Str<sup>R</sup>, 5fu<sup>R</sup>, Nal<sup>R</sup> exconjugants were identified on the basis of screening thousands of colonies developed on R+S+N. Genetic recombination at the level of chromosome transfer was detected as rare events in crosses between genetically-marked sublines of strain I-110 of Rhizobium japonicum.

Mutant strains of soybean nodulating bacteria with nutritional requirements and symbiotic markers isolated - Beltsville, MD. Hundreds of thousands of clones surviving nitrous acid mutagenesis were screened for amino acid auxotrophy by replica plating. Mutants requiring tryptophan (trp<sup>-</sup>), leucine (leu<sup>-</sup>), proline (pro<sup>-</sup>), and histidine (his<sup>-</sup>) were identified, isolated, and then purified. More than 4,500 clones surviving mutagenesis as above were developed into cultures which were then tested for symbiotic performance with soybeans in the field. This massive and unprecedented experimental undertaking resulted in the identification and isolation of mutant clones of Rhizobium japonicum strain I-110 AR with symbiotic markers. Mutants lacking the ability to nodulate the soybean (nod<sup>-</sup>) and those lacking the ability to fix nitrogen (nif<sup>-</sup>) have been isolated. These genetically-marked strains are required for mapping and identifying the bacterial genes required for greater nodulation and more efficient symbiotic nitrogen fixation.

Irrigation as a management tool in soybean production - Stoneville, MS. Irrigation of Tracy and Bragg soybeans prior to bloom significantly increased plant height and grain yield above levels from beans not irrigated, irrigated at bloom, or irrigated at beginning pod fill. The growing season was one of prolonged drought during vegetative development.

Narrow rows planted to determinant type soybeans maximize yield potential in high yield environments - Wooster, OH. Two production factors, solid seeding, and semidwarf varieties show potential for increasing Midwest soybean yields. Research and grower experience has shown that solid seeding has the potential for a 10 - 20% yield increase over 30-inch rows. Research has shown that in high yield environments semidwarf varieties can also result in a 10 - 20% yield increase. When these two production factors are combined, there is an additive effect, resulting in a 30 to 40% yield increase over currently grown varieties in 30-inch rows. Averaged over 2 years, semidwarf line in 7-inch rows averaged 48% higher in yield than Williams (the most popular variety in the Midwest) in 30-inch rows (54 vs 80 bu/A).

#### Peanuts:

Improved irrigation efficiency - Stillwater, OK, in cooperation with Texas Agricultural Experiment Station. 'Florunner' and 'Tamnut 74' peanut plants were grown in rain shelters and provided either 15 or 20 inches of total water for the growing season based on tensiometer readings and computer simulation of evapotranspiration. Water use efficiency (lb pods/inch water) was greatest for both varieties at the lower amount of water.

Screening method for response to climate - Stillwater, OK. Both temperature and daylength have been found to affect peanut plant growth and fruiting in controlled environments. This information can be used for more rapid screening of peanut germplasm to select plants with better tolerance to temperature and daylength conditions that exist in the field. This can lead to development of breeding lines with better tolerance to climate stress while still producing economically feasible yields.

Infrared aerial photographs can be used to detect, estimate, and sometimes reduce disease losses in peanuts - Suffolk, VA. Sclerotinia blight (S. sclerotiorum) produces a characteristic image on infrared photography made from planes at 1,000 - 65,000 feet. Apparent severity as seen on the imagery is directly correlated with actual losses in the fields. Fields interpreted to be slightly, moderately, and severely infected have pod losses 2, 5, and 7 times greater, respectively, than those of nondiseased areas. The photography also shows greater infection by S. sclerotiorum in plants injured by tractor tires during the growing season. Experienced interpreters can use infrared photography made towards the end of the growing season to predict actual disease loss due to a specific pathogen with a characteristic image (as S. sclerotiorum) and then predict whether more applications of fungicides is in order or whether early digging will reduce losses where a late season spread of the disease causes much pod rot.

Chlorothalonil enhances the severity of a nontarget peanut disease pathogen, Sclerotinia sclerotiorum - Suffolk, VA. Chlorothalonil is a fungicide now used extensively for control of Cercospora leafspot of peanuts. At harvest time the number of plants killed by Sclerotinia blight (S. sclerotiorum) and other indications of disease severity are significantly greater in plots treated with chlorothalonil than in plots treated with other standard peanut leafspot fungicides. Pod yields and values per acre are also lower in chlorothalonil treated plots than in the other plots. The reasons for the increase in severity of Sclerotinia blight following treatment with chlorothalonil is not now know. Growers having histories of Sclerotinia blight on their farms are beginning to learn they should not use chlorothalonil for Cercospora leafspot control.

Experimental fungicide especially effective in controlling Sclerotinia blight - Suffolk, VA. Procymidone, applied preventatively or on demand, provided almost complete control of Sclerotinia blight. Yield and value from treated plants was sometimes twice that on nontreated plants.

#### Guar:

Nodulation of guar improved - Vernon, TX. 'Kinman' guar inoculated with Cel-Pril, a composite of heat-resistant Rhizobium strains, produced plants having 36% more nodules per plant than noninoculated seed. Plants grown from inoculated seed were slightly taller with more nodes on the main stem and weighed more than plants grown from noninoculated seed.

# VARIETIES RELEASED

<u>Name or Designation</u>	<u>Maturity Group</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
<u>Soybeans</u>			
Miles	IV	SEA-Maryland AES	Higher yields, greater disease resistance, and greater resistance to shattering than Kent
Wells II	II	SEA-Illinois, Michigan, and Purdue University AES	Resistant to 7 races of phytophora root rot
Cumberland	III	SEA-Iowa, Puerto Rico, Illinois, Indiana, Kansas, Nebraska, and Ohio AES	Superior yield to cultivars of similar maturity
Oakland	III	SEA-Iowa, Puerto Rico, Illinois, Indiana, and Ohio AES	Resistance to Race 1 of phytophora root rot and superior yield
Sloan	II	SEA-Iowa, Puerto Rico, and Ohio AES	Superior yield to cultivars of similar maturity
Vickery	II	SEA-Iowa, Ohio, Puerto Rico, and Indiana AES	Resistant to 8 races of phytophora root rot and high yield
Vinton	I	SEA-Iowa and Puerto Rico AES	Large-seeded specialty variety, high yield, and higher protein
Dowling	VIII	Texas AES-SEA	High yield and adaptation in Gulf Coast area
Bay	V	SEA-Virginia, Delaware, Maryland, and Tennessee AES	High yield and excellent seed quality; adapted to double crop planting

VARIETIES RELEASED

<u>Name or Designation</u>	<u>Maturity Group</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
<u>Soybeans (Cont.)</u>			
Ware	IV	SEA-Delaware and Virginia AES	Excellent seed quality and high yield.
Gail	VI	Texas AES-SEA	Adaptation to high plains of Texas; high yields.
Alamo	IX	Rio Farms, Inc.-SEA	Adaptation to lower Rio Grande Valley of Texas; high yields.

NONCOMMERCIAL GERMPASM RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
<u>Soybeans</u>		
A2	SEA-Iowa and Puerto Rico AES	Superior resistance to iron deficiency chlorosis, a problem associated with calcareous soils. I maturity.
A3	"	Resistance to brown stem rot disease. I maturity.
A4	"	Resistance to brown stem rot disease. III maturity.
<u>Peanuts</u>		
Jenkins Jumbo	SEA-Florida and Georgia AES	Large seed size and keeping qualities and chemical composition of seed.

NONCOMMERCIAL GERMPLASM RELEASED (Cont.)

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
<u>Safflower</u>		
LMVFP-1	SEA	Resistance to lettuce mosaic, verticillium wilt, fusarium wilt, and phytophthora root rot.
14-5	SEA-California AES	Phytophthora root rot resistance.

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National Research Program 20090

BREEDING AND PRODUCTION - SUGAR CROPS

This National Research Program involves research in breeding and production of sugarcane, sugarbeets, and sweet sorghum. New varieties, hybrids, and breeding lines are developed to improve yield, pest resistance, and drought, cold, and salt tolerance. Cultural and management practices are developed that will improve sugar and sirup yields and reduce production costs. Geneticists, plant pathologists, physiologists, and agronomists work as teams within commodities, sometimes with State researchers, to accomplish the mission.

NPS Contact: N. I. James

Technological Objective 1.

Develop new and improved breeding lines and varieties that combine high yielding potential and favored quality characters with better pest resistance, drought-cold-salt tolerance, and adaptation to mechanized culture, harvesting, handling, and storage.

Research Locations:

5205 Salinas, California  
5602 Fort Collins, Colorado  
7613 Canal Point, Florida  
5220 Aiea, Hawaii  
7412 Houma, Louisiana  
1110 Beltsville, Maryland  
1108 Beltsville, Maryland  
3508 East Lansing, Michigan  
7403 Meridian, Mississippi  
3602 Fargo, North Dakota  
5702 Logan, Utah

Selected Examples of Recent Progress:

Sugarbeet:

Eight germplasm lines of sugarbeet released for use by sugarbeet breeders Salinas, CA. Breeding lines resistant to virus yellows, beet mosaic, curly top, and Erwinia soft rot were released for use as sources of resistance. These lines possess resistance to various combinations of the diseases.

Root toughness influenced by environment - Salinas, CA. Two years' data from representative breeding lines and varieties show that environmental influences are significant. There were significant differences among and within varieties for pressure required for penetration of a probe into the root.

Six rhizoctonia root rot resistant breeding lines released - Ft. Collins, CO. Six multigerm breeding lines with improved resistance to rhizoctonia root rot were released for use as pollinators in hybrid combinations. These lines are sufficiently heterogeneous to permit selection for improved combining ability if necessary.

Thirteen breeding lines released with resistance to Cercospora leaf spot or resistance to leaf spot and curly top - Ft. Collins, CO. These releases included six monogerm lines with cytoplasmic male sterility. One line has combined resistance to the two diseases and high vigor, thereby offering the potential for development of single cross sugarbeet hybrids. Single cross hybrids have not been practical because of low seed production by nonvigorous seed parent lines.

Breeding line released with potential to increase sugar production by 5% in Michigan - Beltsville, MD. The male-sterile equivalent of a monogerm O-type in a 3-way hybrid increased production of sugar per hectare by 5% and grower income by \$62 per hectare.

Sugarbeet plants regenerated from callus cultures - Beltsville, MD. Callus cultures were obtained from sepals and ovaries. Some plantlets regenerated from these cultures appear to be normal sugarbeet plants in greenhouse pots. Callus cultures from anthers cannot yet be obtained.

Progenies of plants selected for high taproot to leaf weight ratio significantly higher than low ratio progenies in sucrose, clear juice purity, and sugar per ton - East Lansing, MI. In field tests, progenies of plants selected for three generations in a growth chamber for high taproot to leaf weight ratio were significantly higher for three quality characteristics than progenies of plants selected for low ratio under the same conditions. In breeding programs, selection for plants that partition a larger proportion of the available photosynthate to the root may result in improved quality.

Low respiring genotypes reduce sucrose storage losses - Fargo, ND. Internal CO<sub>2</sub> level in the sugarbeet root is a measure of respiration rate. Four genotypes were developed that average 36% lower internal CO<sub>2</sub> level than four commercial cultivars. Roots of one low respiring line lost 40% less sucrose in storage than a commercial cultivar.

Genotypes resistant to Phoma betae in storage are also resistant in the seedling stage - Fargo, ND. Three breeding lines developed for resistance to storage rot caused by Phoma betae were more resistant to infection by this pathogen in the seedling stage than susceptible cultivars. This finding suggests that genotypes resistant to storage rot caused by this organism can be selected in the seedling stage of growth in less time and with less expense.

Evaluation of taproot to leaf weight ratio as a selection criteria to improve sugarbeet production - Logan, UT. A field pilot study was conducted to compare selections of high- and low-hypocotyl diameter and high- and low-taproot to leaf blade weight ratio with the parent

population. The high taproot to leaf blade weight ratio selection had the highest root yield in the test and was significantly better than the parent population for sugar content.

Third cycle of selection was effective in reducing damage caused by sugar-beet root maggot - Logan, UT. A correlation of -0.73 was found for vigor versus damage rating, and the populations selected for low damage also exhibited better plant vigor than the parent population. Selection for root maggot resistance was initiated in a new heterogeneous population.

#### Sugarcane:

Four new high yielding sugarcane varieties developed for Florida - Canal Point, FL. CP 71-1027, CP 71-1086, CP 71-1194, and CP 71-1442 produced on the average of three crops 112, 130, 116, and 125% more sugar per hectare, respectively, than the major commercial variety, CP 63-588. These varieties must be evaluated for reaction to two diseases new to Florida, sugarcane smut and sugarcane rust, before they are considered for release.

U.S. mainland sugarcane varieties evaluated for reaction to sugarcane smut in Jamaica - Canal Point, FL. Under cooperative agreement with the Sugar Industry Research Institute, Mandeville, Jamaica, 280 mainland sugarcane varieties were evaluated for smut reaction in the plant cane crop. Plans are to evaluate about 600 clones in the plant and first ratoon crops. Data collected in Florida in cooperation with the U.S. Sugar Corporation since sugarcane smut was found in Florida in June 1978 do not indicate race differences in Florida and Jamaica.

Environment influences sugarcane flowering - Aiea, HI. Climatological data and flowering data on 10 commercial varieties show that 1) years with greatest summer rainfall, especially in August, are the heaviest flowering years; 2) time of floral induction and time of flowering differ from year to year among varieties and between plant and ratoon crops; 3) period of induction and time of flowering are delayed and occur over a longer time period in dry years than in wet years, and 4) within a variety early induction is associated with heavier flowering and late induction with lighter flowering.

Development of haploid cell lines in tissue culture proves difficult - Aiea, HI. Numerous treatments and media were tried to develop haploid cell lines from anther culture. Pretreatment of excised stalks with low temperature of 6 to 7° C for 24-168 hours increased the period of anther survival and the number of nuclei produced within pollen grains. The longest cold treatment supported 10 to 15 nuclei per pollen grain, but development was slow with 2-3 days required per division and haploid callus was not obtained.

Two improved sugarcane varieties released for commercial production in Louisiana - Houma, LA. Fourteen years of variety development research culminated in the release of two commercial varieties that are resistant to the sugarcane borer and moderately resistant to sugarcane mosaic

virus. CP 70-321 equaled the mosaic-susceptible leading variety, CP 65-357, in yields of cane and sugar per hectare and appears to be cold tolerant. CP 70-330 is adapted to heavy soils, performs well in stubble crops, but is susceptible to freeze damage.

New sugarcane germplasm introduced - Beltsville, MD. There were 783 sugarcane clones imported from 15 countries or States and placed in quarantine. Of this number, there were 288 clones collected as new germplasm in Indonesia and New Guinea or imported from the collection in India because they were not present in the germplasm collection at Miami, Florida. Many of the new introductions are resistant to sugarcane smut, a disease new to the U.S. mainland. This disease was identified in Florida in 1978.

Enzyme-linked immunosorbent assay (ELISA) lacks accuracy required for ratoon stunting disease determination - Beltsville, MD. Extensive data show that the ELISA method is not sufficiently accurate to screen for resistance to ratoon stunting disease. This method has received much attention as a method of detecting and/or screening for plant virus diseases, but it is not adequate to detect this plant bacterial disease. Pathologists should not assume that ELISA is a technique of universal importance.

#### Sweet Sorghum:

New sweet sorghum variety released for sugar production - Meridian, MS. Wray, a new sweet sorghum variety for sugar production, is superior to Rio in yield of stripped stalks, sugar per ton of stalks, and sugar per hectare. The new variety has fewer leaves, smaller seed heads, fewer side branches, and is more resistant to lodging than Rio. These characteristics will reduce trash content of harvested stalks and reduce sugar losses in processing.

#### Technological Objective 2

Develop new and improved cultural and management practices to increase sugar and sirup yields, minimize production losses, improve quality attributes, and efficiently conserve scarce resources.

#### Research Locations:

5205 Salinas, California  
5602 Fort Collins, Colorado  
7613 Canal Point, Florida  
5220 Aiea, Hawaii  
7412 Houma, Louisiana  
1110 Beltsville, Maryland  
3508 East Lansing, Michigan  
7403 Meridian, Mississippi  
3602 Fargo, North Dakota  
5702 Logan, Utah

Selected Examples of Recent Progress:

Sugarbeet:

Legume yellows virus closely related to beet western yellows virus - Salinas, CA. A new virus attacking California legumes including alfalfa, peas, chickpeas, and forage crops has been found and characterized. It is capable of inducing severe losses on some of these crops. The virus differs markedly from beet western yellows virus in host range and vector specificity but was shown to be closely related in reciprocal infectivity neutralization tests.

Benomyl resistant strains of Cercospora beticola compete in natural populations - Fort Collins, CO. After 3 years of successful use, benomyl failed to control Cercospora leaf spot in the Wilcox area of Arizona due to the development of benomyl-resistant fungal strains. From 1976 through 1978, isolates from benomyl-sprayed, triphenyltin-sprayed, and nonsprayed areas near Wilcox continued to have high levels of benomyl resistance as determined by bioassays in vitro. Thus a moratorium on benomyl use for 3 years was insufficient to restore dominance of benomyl-sensitive strains in natural populations of the fungus, even when triphenyltin was used for leaf spot control. The competitive ability of the tolerant strains precludes benomyl use once such strains become predominant in an area where sugarbeet is grown.

Cultural practice increases rhizoctonia root rot - Fort Collins, CO. A cultural practice called ditching out by sugarbeet growers often deposits soil in and around the crown of the sugarbeet plants. In a field experiment, this practice was shown to reduce harvestable roots 20 and 6% in a commercial cultivar and a rhizoctonia-resistant line, respectively, due to an increase in fungal root rot caused by Rhizoctonia solani.

Infrared aerial photography used to estimate disease severity - East Lansing, MI. In research plots, infrared aerial photography disease estimate ratings showed a high degree of correlation with percent rhizoctonia root rot ( $r = .94$ ) and with powdery mildew severity ratings ( $r = .96$ ).

Effect of nitrogen on sugarbeet quality and crown tissue production - Fargo, ND. Crown tissue production increased linearly as N was increased. Root yield remained fairly constant after soil and added N was increased above 225 kg/hectare. Purity and sucrose decreased and Na, K, and amino-N increased in both root and crown tissue as N rates increased. The data showed that excessive crown production could be minimized by controlling the rate of N.

Pleospora bjorlingii, the sexual state of Phoma betae found in Oregon seed fields - Fargo, ND. Examination of sugarbeet seed stalk debris from seven fields revealed the Pleospora state of the fungus was present in each of the seven fields. This is the first evidence that this fungus exists in the U.S. and overwinters as the Pleospora state.

Improved storage management practices reduce sucrose losses during root storage - Logan, UT. During the last 8 years, improved storage management practices were developed that are capable of reducing sucrose losses during commercial root storage by 50 percent. Significant findings include the importance of minimizing harvest injury, use of the fungicide, Mertect, to control rots, genetic control of respiration rates, and the development of a computer simulation model of a sugarbeet storage pile. Using the model, improved storage practices, such as forced ventilation cooling, were developed and evaluated.

Systemic insecticide will protect sugarbeets from the curly top virus disease - Logan, UT. Field tests using the systemic insecticide phorate indicated that the insecticide treatment protected a susceptible sugarbeet cultivar from losses due to curly top virus disease about as well as the genetic resistance of a resistant cultivar. Several factors favor use of resistant cultivars to control the curly top disease but if susceptible cultivars are used in an area where curly top disease potential is high, then systemic insecticide treatment should be used to insure good production.

Sugarcane:

Increased sugarcane growth in response to serial applications of gibberellic acid - Aiea, HI. Gibberellic acid (GA<sub>3</sub>) is used in the Hawaiian sugarcane industry to overcome poor winter growth and increase yields. With a given amount of GA<sub>3</sub>, growth in response to serial applications was more than twice the growth in response to a single application. Increased effectiveness of GA<sub>3</sub> improves the economics of its use. It is estimated that serial applications of GA<sub>3</sub> increased yields in the Hawaiian sugarcane industry by more than 5,000 tons in 1978.

Yield potential of sugarcane in Louisiana is increased by narrow row spacings - Houma, LA. Results from small and large plot tests indicate the yield of sugarcane in Louisiana is potentially two to three times the State average. Small plot tests average 170 tons per hectare for very close row spacings. Yields from narrow rows were twice that of standard rows in a large scale test. Plantings in three locations were satisfactorily harvested by several standard models of mechanical harvesters indicating that narrow row spacing in sugarcane has pragmatic potential.

RSD-associated bacterium not related to Pierce's disease bacterium or the genus Actinomyces - Beltsville, MD. Serology tests were performed with RSD-antiserum against antigens or with the RSD-associated bacterium against other antisera. These tests showed that the RSD-associated bacterium was not related to the Pierce's disease bacterium or to bacteria in the genus Actinomyces.

Sweet Sorghum:

Close row spacing increases yield slightly - Meridian, MS. Sweet sorghum on 61-cm rows produced slightly more stalks per hectare than on normal row widths of 106 cm. Plants grown on narrow rows had higher percent leaves and lodged more than those grown on normal row spacings. Juice brix, sucrose, and purity were not affected by row width.

# VARIETIES RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
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## SUGARCANE

CP 70-321

SEA, Louisiana AES, and  
American Sugar Cane League

Borer resistant; moderately  
resistant to mosaic; adapted to  
machine harvesting; moderately  
high in sucrose and purity.

CP 70-330

SEA, Louisiana AES, and  
American Sugar Cane League

Borer resistant; high sucrose;  
moderately resistant to mosaic;  
well suited to machine harvesting.

## SWEET SORGHUM

Wray

SEA; Louisiana, Mississippi,  
and Texas AES

High yield of sugar per hectare;  
adapted to Louisiana, Mississippi,  
and Texas.

# NONCOMMERCIAL GERMPLASM RELEASED

## SUGARBEET

FC 502/2

SEA, Colorado AES, and Beet  
Sugar Development Foundation

Monogerm, diploid; resistant to  
Cercospora leaf spot.

FC 502/2 CMS

" " " " " "

FC 504

" " " " " "

FC 504 CMS

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FC 506

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FC 506 CMS

" " " " " "

Name or DesignationRelease AgenciesReason for Release

## SUGARBEET

FC 604

SEA, Colorado AES, and Beet  
Sugar Development FoundationMonogerm, diploid; resistant to  
leaf spot and curly top virus

FC 604 CMS

" " "

" " "

FC 605

" " "

" " "

FC 605 CMS

" " "

" " "

FC 606

" " "

" " "

FC 606 CMS

" " "

" " "

FC 702/4

" " "

Multigerm; rhizoctonia root rot  
resistant

FC 702/4 (4X)

" " "

" " "

FC 704

" " "

Marker plant with red roots and  
leaves

FC 705

" " "

Multigerm; rhizoctonia root rot  
resistant

FC 706

" " "

" " "

FC 707

" " "

" " "

FC 902

" " "

Multigerm; leaf spot-curly top  
resistant

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
SUGARBEET		
L 19	SEA, Utah AES, and Beet Sugar Development Foundation	Multigerm, diploid; high sugar content
L 35	" " "	Monogerm, diploid; resistant to curly top
L 35 CMS	" " "	" " "
L 36	" " "	" " "
L 37	" " "	Multigerm, diploid; good combining ability for root yield
L 38	" " "	" " "
L 53	" " "	Multigerm, diploid; low respira- tion rate
L 53 CMS	" " "	Multigerm, diploid; good combining ability
L 60	" " "	Multigerm, diploid; pollen fertility restorer breeding line
L 61	" " "	Monogerm " "
C 16	SEA and Beet Sugar Develop- ment Foundation	Multigerm, diploid, maintainer line
C 16 CMS	" " "	" " good combining ability
C 19	" " "	Multigerm; bolting resistant; high yield

Name or DesignationRelease AgenciesReason for Release

## SUGARBEET

C 19	SEA and Beet Sugar Development Foundation	Multigerm; bolting resistant; high yield
C 19 CMS	" "	" "
C 32	" "	Multigerm; resistant to beet mosaic virus
C 43	" "	" "
C 779	" "	Monogerm; diploid; resistant to virus yellows
C 779 CMS	" "	" "
SP 70756-0	" "	Resistant to Cercospora leaf spot and Aphanomyces black root
SP 73747-0	" "	" "
SP 74566-0	SEA, Michigan AES, and Beet Sugar Development Foundation	" "
SWEET SORGHUM		
P.I. 152857	SEA, Mississippi A&FES, and Texas AES	Germplasm from which most commercial sweet sorghum varieties were developed
P.I. 152959	" "	" "
P.I. 152965	" "	" "
P.I. 152967	" "	" "
P.I. 152971	" "	" "
P.I. 154844	" "	" "

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## National Research Program 20100

### BREEDING AND PRODUCTION - FORAGE CROPS FOR HAY, PASTURES AND OTHER USES, INCLUDING TURF

This National Research Program outlines a research program on crop production efficiency to develop new knowledge and to increase crop and livestock productivity. Forage crops for hay, pasture, silage, and other uses, including turf; and grass and legume seed production represent a resource of major economic significance in the United States.

NPS Contact: R. F Barnes

#### Technological Objective 1.

New and improved genetic populations, breeding lines, and cultivars of forage crops with improved yield, special use characteristics, quality, pest resistance, and tolerance to environmental stress.

#### Research Locations:

3611	Palmer, Alaska
7702	Tifton, Georgia
3420	Manhattan, Kansas
7809	Lexington, Kentucky
1108	Beltsville, Maryland (PPGI)
1109	Beltsville, Maryland (PPHI)
3502	St. Paul, Minnesota
7502	Mississippi State, Mississippi
3416	Lincoln, Nebraska
5208	Reno, Nevada
1307	Ithaca, New York
7802	Raleigh, North Carolina
3605	Mandan, North Dakota
1302	University Park, Pennsylvania
1402	Wyndmoor, Pennsylvania
7708	Clemson, South Carolina
7302	College Station, Texas
7307	Temple, Texas
7811	Blacksburg, Virginia
5806	Prosser, Washington
3507	Madison, Wisconsin

#### Selected Examples of Recent Progress:

Tifton 44 bermudagrass better than Coastal - Tifton, GA. Tifton 44 bermudagrass, the best of several thousand F<sub>1</sub> hybrids between Coastal and a bermudagrass found in Berlin, Germany was registered and released in 1978. Evaluation by USDA and State scientists from several disciplines

in 14 States proved Tifton 44 to be equal to Coastal in disease resistance, yield, and adaptation and superior in winterhardiness and quality, giving 19% better average daily gains when grazed or fed as pellets. Sprigs of Tifton 44 were distributed to 263 certified growers who drove from central Texas to the Atlantic to get the grass on 5/3/78 and 6/21/78. Tifton 44 can be grown dependably in a belt 500 miles wide from the Atlantic to central Texas. A million acres can be planted by 1982, adding some 50 million pounds more beef than would have been available from a similar acreage of Coastal bermudagrass.

Discovery of sexual plants provides new parents for hybrid buffelgrass - College Station, TX. Buffelgrass normally reproduces by apomixis, a process in which the embryo of the seed develops from tissue of the mother plant without fertilization by a male parent. Hybridization and breeding of purely apomictic plants is impossible. A single sexual plant discovered in 1958 provided the first opportunity to cross buffelgrass plants and develop improved varieties. However, sexual female parents with different characteristics were needed to develop better hybrids. In 1978 promising new sexual plants were discovered in an introduction collected in South Africa. These plants will permit development of a much wider range of new buffelgrass hybrids.

New introductions promise better winter-hardiness in buffelgrass - College Station, TX. Buffelgrass is used extensively in south Texas, Mexico, and other arid countries for revegetation and grazing. It is very drought resistant but lack of cold tolerance restricts it to areas with mild winters. Cold hardy strains would be useful in much of the Southwest. New rhizomatous hybrids have better winter survival because the rhizomes are covered with soil, but plants with cold tolerant tissue are needed to survive low temperatures. New introductions collected in the high altitudes of South Africa survived 18° F in 1977-78. These strains are being hybridized with rhizomatous types to combine tissue tolerance with the protection from cold afforded by deep rhizomes.

Facultative apomixis discovered in buffelgrass - University Park, PA and College Station, TX. We found that certain lines of buffelgrass are facultatively apomictic, that is seed can be formed both by sexual reproduction and by asexual reproduction (apomixis). Microscopic studies showed that both sexual and asexual embryo sacs could be formed by certain plants. Field tests of the progeny showed that most progeny resembled the maternal parent (i.e., were apomictic) but a few progeny were different (i.e., sexual hybrids). The significance of this discovery is that now plant breeders will be able to recover new genetic types of buffelgrass in a single generation of selection from a facultatively apomictic parent, thus saving time and effort in achieving development of new varieties.

Trichomeless pearl millet reduces water transpiration - Tifton, GA. The trichomeless mutant in pearl millet has one-third as many cracks in the cuticle of the leaf as does normal trichomed (hairy) pearl millet. The more perfect leaf surface apparently reduces transpiration and appears to impart drought tolerance. Discovery of the cracking characteristic should be useful in studies to further modify the cuticle.

Discovery of dhurrin in indiangrass - Lincoln, NB. In 1902, sorghums were found to contain dhurrin, a compound that yields hydrocyanic acid when broken down by an enzyme. In the years since 1902, dhurrin was not definitely identified in any plants other than sorghum until 1978 when it was discovered that young seedlings of indiangrass (Sorghastrum nutans) also contained dhurrin. Indiangrass is a warm-season perennial prairie grass commonly grown in the pastures and rangelands of the Great Plains region. No reports of cattle deaths due to grazing indiangrass are known; therefore, the occurrence of dhurrin in this grass does not appear to be a problem.

Extensive kleingrass collection assembled - Temple, TX. Panicum coloratum (kleingrass) germplasm has been assembled from around the world through plant introduction stations and personal contact with other researchers in the USA and abroad. This germplasm, probably the most extensive working collection of kleingrass ever assembled, will be the basic germplasm for a breeding program with this most important forage species. Kleingrass acreage in Texas was estimated at 620,000 acres in 1977 and is increasing rapidly.

Seasonal trends in lovegrass forage quality revealed - Temple, TX. Little information is available on the forage quality of weeping lovegrass. By using three management levels on four selections a broad range of information was produced with limited investment in time and funds. Results documented a rapid spring decline in quality associated with increasing cell walls. Changes during regrowth were smaller. Stage of growth at harvest during spring reproductive phases is critical to maintaining good quality. Although age of regrowth can affect quality, the changes are not as rapid, nor is the level ever as high as in first growth. Therefore, management decisions on when to graze or make hay will have less dramatic impact.

Maturity accounts for only part of varietal differences in lovegrass forage quality - Temple, TX. Varietal differences in forage quality are sometimes associated with maturity differences. Later selections of weeping lovegrass tend to be higher in IVDM. It has not been clear if the differences in quality are caused by the late maturity or if other factors are involved. Our results indicate that harvesting varieties of lovegrass at similar stages of growth tended to reduce, but not eliminate differences in IVDM and other forage quality attributes. Thus, maturity appears to account for part but not all of the forage quality differences among weeping lovegrass varieties.

Management important in evaluation of range grasses - Temple, TX.

Blue grama, sand bluestem, and indiangrass selections were grown with two levels of fertility. Sand bluestem and indiangrass selections performed similarly under both fertility treatments. However, blue grama entries performed very differently at the two fertility levels. Experimental strain WW-65 was among the lowest in IVDMD and crude protein when evaluated with 33 lb N/A each year. Without added fertility its performance was relatively better. Experimental varieties must be tested under several managements if they are going to be adequately evaluated.

Easily measured anatomical characteristics in Kentucky bluegrass found useful in estimating forage quality and in cultivar identification - University Park, PA. Hand sectioning and staining of cross sections of leaves of Kentucky bluegrass revealed anatomical characteristics that were easily identified and measured. Using this technique, large numbers of plants could be screened for forage quality with less expense than would be required using in vitro procedures. Leaf anatomy can also be used as an aid in cultivar identification in Kentucky bluegrass.

Assembly of orchardgrass germplasm - Beltsville, MD. We have received the entire research collection of interspecific hybrids among four subspecies of Dactylis glomerata from Dr. David Timothy of North Carolina State University. The collection is represented by more than 2,000 crosses of mostly diploid forms of D. glomerata, of unknown economic potential. This collection along with new plant introductions from the Soviet Union, collected by Dr. Doug Dewey, USDA-SEA, Logan, Utah, will provide significant new germplasm for breeding orchardgrass in the U.S.

Resistance to potentially important new disease found - University Park, PA. A leafspot disease caused by a fungus of the species Septoria was found to cause severe damage on reed canarygrass being irrigated with wastewater for the disposal of municipal sewage effluent. Individual plants with high resistance to the disease were found by inoculation of reed canarygrass in the greenhouse. Other grasses and cereals were found to be highly resistant or immune. The significance of this work is that the basis for control by selection for resistance has been established. Reed canarygrass can be retained as the favored species for use in land disposal of wastewater.

Influence of tall fescue varieties on grazing steers during summer and fall - Lexington, KY. Kenhy tall fescue produced 60% higher average daily gains than Ky 31 during summer and fall. Yearling steers weighing 294 kg initially were randomly assigned to the varieties which were replicated in 1.61 ha fields. Utilization of Kenhy may help overcome the fescue toxicosis problem which at times reduces gains by 50% or more with grazing cattle.

Relationship of temperature to summer fescue toxicosis - Lexington, KY. Two tall fescue strains, G1-306 and G1-307, with large differences in perfoline alkaloid content, were compared when fed to young Holsteins (100-200 kg) in controlled temperature rooms (10-13C and 34-35C). All calves were fed ad. lib. soilage twice daily. Animal performance was superior for the G1-307 (low alkaloid) at the low temperature; but, at 34-35C, G1-307 intake was reduced 50%. The results demonstrate that summer toxicosis is related to environmental temperature and that the G1-307 contains more toxic substances.

Haploid plants from anthers of tall fescue - Lexington, KY. Haploid plants ( $n=21$  chromosomes) of tall fescue ( $2n=42$ ) were obtained from anthers when cultured with nurse tissue of the parent plant on a modified Murashige and Skoog medium. Examination of root tips revealed that nearly all of 30 green, vigorous plants were haploid. Time required to fix characters of economic importance into true breeding lines and varieties will be cut by approximately 70-80% by utilizing haploid lines as a gametic selection scheme.

Breeding methodology established for improving nitrogen fixation in alfalfa - St. Paul, MN. Two alfalfa populations were selected for increased N-fixation estimated by the acetylene reduction (AR) method. AR rates after two cycles of recurrent selection were 65 to 70% greater than those of the two original populations. Selection for increased root nodule mass, fibrous roots, and top weight also led to increased AR. However, only nodule mass accounted for a major part of AR variation. Selection for large plants with many nodules followed by AR assay appears to be the most effective large scale screening program. AR provides estimates of both plant characteristics and specific rhizobium activity.

Verticillium wilt resistant alfalfa - Prosser, WA. An experimental alfalfa cultivar (W35) was developed with bacterial wilt resistance equivalent to Ranger and Verticillium wilt resistance slightly less than Vertus. It also has resistance to Fusarium wilt and stem nematode. Forage yields for 1 year were superior to Vernal and equal to DuPuits in the absence of Verticillium wilt. This cultivar, when released, should be useful in maintaining forage production in the Pacific Northwest.

Verticillium wilt of alfalfa found widespread in Pacific Northwest - Prosser, WA. Verticillium infested areas comprise about 50% of the 1 million acres of alfalfa in the Northwest. Increasing severity of this disease results in hay and stand losses so that maximum life of a planting may be 3 years instead of 6 or 7 years. Development of resistant cultivars is imperative to the alfalfa industry. To enable alfalfa breeders to search for resistant varieties, a standardized procedure to test or screen alfalfa against the alfalfa strain of V. albo-atrum has been developed by AR scientists.

New strain of anthracnose fungus - Raleigh, NC and Beltsville, MD. A highly virulent isolate of Colletotrichum trifolii was recovered from alfalfa cultivars that were previously resistant to this fungus. Germplasm adapted to the Southeast was evaluated for resistance to this important disease in humid areas and a source of germplasm has been found with low to moderate levels of resistance. Work has begun to increase resistance to this new strain of the fungus.

Host resistance selection for foliar diseases of alfalfa - Reno, NV. Significant progress has been made in using field epiphytotics of foliar diseases for host resistance selection at Salinas, CA. The most susceptible germplasm has shown a decrease of .5 in The Average Severity Index for common leafspot per selection cycle. Common leafspot causes heavy economic losses to the hay industry in the Eastern Seaboard, the North Central States, the Midwest, the Pacific Northwest, and from Central to Southern California. Losses occur both in quantity and quality of hay.

Riley alfalfa - Manhattan, KS. Riley alfalfa provides protection against multiple pests. Riley has a high level of resistance to pea aphid, spotted alfalfa aphid and bacterial wilt. It has moderate resistance to rust and downy mildew. Resistance of Riley to potato leafhopper yellowing is about equal to that of Cherokee. Riley has shown resistance to anthracnose in the field and has shown more resistance to summer black stem than any other cultivar tested in Kansas. It has been estimated that the new variety could add from \$50 to \$100 million annually to the gross income of Kansas alfalfa growers.

More vigorous arrowleaf clover developed - Tifton, GA. A population of arrowleaf clover developed by the recurrent restricted phenotypic selection approach has superior seedling vigor when compared to available cultivars. This species has small seed and is slow to establish unless conditions are optimum. The added vigor of this population promises to speed establishment and hence winter survival. Yield comparisons are not complete but appear to show this population superior to commercial strains in several States.

Legume viruses are serious pests - Blacksburg, VA, Clemson, SC, and Raleigh, NC. Research in 1978 and earlier has shown that viruses of forage legume species are very widespread and contribute to stand losses and lack of persistence. The perennial nature of these legumes makes them ideal overwintering host plants. White clover clones infected with viruses have had a very poor survival rate with significant losses even during the first growing season but especially over the winter. Forage production is visibly affected by virus infections. Results to date indicate that virus resistance or tolerance is needed for maximum forage production and persistence.

Measurements of virus damage on arrowleaf and white clovers have clearly documented the importance of virus diseases on these crops and the need for control measures. The results of our multiple-step screening program designed to identify resistance to AMV, CYVV, and PSV in white clover

show that resistance exists in the species. A recurrent selection program is being followed to concentrate resistance to the different viruses into a strain or cultivar of white clover that has desirable agronomic characteristics.

Field collection net for head weevil research - Mississippi State, MS .  
A net has been designed and constructed which can be pulled behind a small trail motorcycle for collection of adult clover head weevils. The use of this net is expected to reduce by 75% the number of man-hours necessary to collect large quantities of adult weevils.

Phytophthora root rot diseases discovered on annual clovers - Mississippi State, MS. Phytophthora root rot diseases were discovered at two locations in Mississippi in 1978. Arrowleaf clover is highly susceptible to Phytophthora megasperma. This is the first report of Phytophthora disease in arrowleaf clover and is believed to be the primary disease in reduction and loss of stands in arrowleaf clover.

Regeneration of clover plantlets through tissue culture - Madison, WI.  
Red clover plantlets have been established through the use of tissue culture procedures. Callus tissue is obtained from seedling tissue and through the process of regeneration plantlets are developed. The process of regeneration through callus development appears to be genetically controlled. Plant breeders should be able to develop a population with the potential of regeneration. Once established the population could be used for variant selection on a single cell basis in the laboratory rather than by expensive field studies.

Red clover plants with Fusarium resistance being assembled - University Park, PA. Considerable insight into the root-Fusarium interaction was gained through the combined field, greenhouse, and slant-board investigations. Progress was made in establishing a pool of red clover plants resistant to specific isolates of F. roseum var. accuminatum, and a study was initiated to determine the heritability of Fusarium resistance.

Release of aphid resistant red clover germplasm - Lincoln, NB. An experimental red clover synthetic was developed with high levels of resistance to the pea aphid and the yellow clover aphid. This red clover synthetic was jointly released by USDA and the Nebraska Agr. Exp. Station as a germplasm source designated as 'N-2'. This release makes available to public and private red clover breeders a source of resistance to these 2 red clover pests for which resistance was not previously available.

## Technological Objective 2.

New and improved cultural and management practices that increase forage crop yields, minimize production and utilization losses, improve feed quality, conserve and use scarce resources efficiently, and enhance environmental quality.

Research Locations:

3611	Palmer, Alaska
7602	Gainesville, Florida
7702	Tifton, Georgia
7903	Watkinsville, Georgia
3302	Lafayette, Indiana
1109	Beltsville, Maryland (PPHI)
3502	St. Paul, Minnesota
7502	Mississippi State, Mississippi
3402	Columbia, Missouri
1307	Ithaca, New York
7802	Raleigh, North Carolina
7318	El Reno, Oklahoma
1302	University Park, Pennsylvania
1400	Philadelphia, Pennsylvania

Selected Examples of Recent Progress:

Alfalfa growth model - Lafayette, IN. Post harvest stubble and root mass determinations were obtained over a 3 year period in a single stand of alfalfa. Root samples obtained in 1977 from the same field previously sampled in 1975 exhibited a seasonal pattern of root mass fluctuation closely resembling seasonal variations in alfalfa root carbohydrates reported in the literature. These determinations will provide accurate initial plant parameters in the alfalfa growth model (SIMED), replacing previous estimations.

Chloroplast starch accumulation - a programmed process - Beltsville, MD. We have found that starch accumulation rate in the chloroplast of soybean leaves can be altered by changing the length of the photosynthetic period and/or dark period. This provides a system for studying the in vivo controls of photosynthate partitioning in leaf chloroplasts. Furthermore, it suggests that starch accumulation rate is a programmed process and not the result of a bottleneck in translocation.

Rapid separations of proteins - Philadelphia, PA. Rapid separations of proteins have been accomplished by size-exclusion, ion-exchange, and reversed phase chromatography and greater understanding of the principles influencing the separations has been achieved. Current studies will lead to routine application of these techniques to the examination of leaf protein isolates.

Infrared reflectance technology promises savings in forage analysis - University Park, PA. Research on use of near infrared reflectance (IR) technology for evaluating forage quality was continued and computer programs were developed to increase efficiency of IR in this application. Using an instrument with a scanning monochromator, small computer, and other peripheral equipment, a forage sample can be assayed, with satisfactory accuracy, for several quality characteristics in less than two minutes. It is believed the procedure can result in savings of 60-70%

of the cost of conventional chemical analyses of forages. The process appears to have great potential usefulness in forage-crops breeding, management studies, animal nutrition research, extension programs, ration formulation, and hay grading and marketing.

Associative effects between *Azospirillum* and tropical forage grasses - Gainesville, FL. Plants in liquid nutrient solutions continued to excrete both amino acids and carbohydrates into the solution even as they approached maturity. *Azospirillum* or other diazotrophic bacteria multiplied when inoculated into the solution, whether or not additional carbon sources were added. However, inoculation did not improve the condition of the plants and often was harmful. Plants nearing maturity were less tolerant to reduction of the mineral nitrogen supply when inoculated with *Azospirillum* than when not inoculated. Even in such conditions, dinitrogen fixation by the inoculant organism was not detected. Several lines of evidence show that competition between the plant and *Azospirillum* can occur under stress conditions, and that in some cases the bacteria can induce collapse of the plant. This seems to provide some further evidence that beneficial effects of inoculation with *Azospirillum* occur early in the life of the plant, and that the stimulus from the inoculant organism is not provided by its capability to fix nitrogen.

Natural drying before dehydrating alfalfa conserves energy - Lincoln, NB. Dehydrated alfalfa has been an important component of livestock and poultry rations in the United States for more than 40 years. Natural gas has been used primarily to artificially dry alfalfa that was field-chopped while green, referred to as the direct-cut method. Research was conducted on producing dehydrated alfalfa by two methods: 1) direct-cutting versus 2) field-wilting (i.e. using sunshine and wind to reduce moisture in field windrows before field-chopping and dehydrating). Commercial field-wilting has become a common practice, and has increased production 10 to 50% while gas usage decreased 10 to 40%. Dehydrated alfalfa produced by the two methods was of equal value in cattle growth and lamb digestion trials.

Sequences of grass-legume mixtures for quality forage production - Mississippi State, MS. Annual and perennial *Trifolium* species grown in sequences have provided 12-month production of grass-legume forage. Proper use and management of clovers in these systems should result in a savings of labor and machinery costs involved in the production, handling, storage and preservation of feed for livestock and reduced costs of nitrogen fertilizer.

Species mixtures maximize forage legume production - Mississippi State, MS. Annual clovers mixed with red clover provide greatest distribution of yield and higher total forage production. Tibbee crimson clover makes more fall and winter growth than other winter legumes. A mixture of Tibbee crimson clover with red clover provides maximum forage for grazing throughout the growing season.

Best forage species identified for utilization of municipal sewage effluent - St. Paul, MN. A 5-year experiment revealed that perennial forage grasses are more efficient utilizers of municipal sewage effluent than is corn or alfalfa, and that reed canarygrass is the best of seven perennial grasses for removing ecologically undesirable nutrients from effluent. Corn fodder yielded more forage than did reed canarygrass, but the grass extracted more than twice as much nitrogen and significantly more phosphorus and potassium from soil irrigated with effluent. Feed quality of all tested crops was not adversely affected by sewage effluent, but instead the effluent caused higher protein concentrations and sometimes higher digestibility of the crops for ruminant animal use. The USDA-SEA team of agronomists and soil scientists demonstrated that it is feasible to grow both perennial grasses and corn in sewage effluent renovation systems.

Cattle gains from warm-season grasses - Columbia, MO. Positive cattle gains (up to 1.3 lb average daily gain) were maintained nearly the entire grazing season by using the warm-season grasses, caucasian blue-stem and switchgrass in pasture systems with cool-season grasses. Previous research showed that weight losses of up to 1 lb/day were not unusual during July and August while grazing a single cool-season grass such as tall fescue or orchardgrass during these hot months in Missouri. Our results provide the farmer with options for bridging the summer slump in pasture production.

Production of beef from tall fescue-legume pastures - Columbia, MO. Results show that production of beef from tall fescue-legume pastures will equal or exceed animal production from tall fescue pastures which are annually fertilized with 141 kg N/ha at a cost of near \$62.00/ha. Average daily gain (ADG) of Hereford x angus steers was 41% greater on 'Kentucky 31' tall fescue pastures sod-seeded with 'Empire' birdsfoot trefoil or 'Kenstar' red clover as compared to tall fescue grown alone and fertilized with 141 kg N/ha. Cattle gains per ha were not statistically different among nitrogen fertilized fescue and fescue-legume pastures. Nitrogen fertilized fescue averaged 343 animal unit (AU) days of grazing/ha, 0.34 kg ADG, and 197 kg gain/ha. Fescue-red clover and fescue-birdsfoot trefoil pastures respectively, averaged 281 and 249 AU days/ha, both averaged 0.48 kg ADG, and beef gains were 214 and 186 kg/ha.

Evaluation of eight forage combinations for winter stockering-summer finishing of steers - Watkinsville, GA. Eight forage combinations were studied for winter stockering-summer finishing of steers using rye, Kentucky-31 tall fescue and Coastal bermudagrass pastures in the Southern Piedmont. Both winter and summer treatments significantly affected final market weight. Carcass traits were not significantly affected. The best winter-summer forage system for producing finished steers in terms of overall weight gains was rye interseeded in dormant bermudagrass followed by limited grain on bermudagrass. The poorest system was Kentucky-31 tall fescue during both winter and summer phases.

Evaluation of warm-season perennial forages - Raleigh, NC. Animal response and plant persistence of several new warm-season perennial forages were obtained. The severe winter of 1977-78 delayed spring growth of Pennisetum flaccidum and weakened P. orientale so it could not be grazed during 1978. Steer gains from the tall fescue plus Coastal bermudagrass control averaged 0.63 kg/day compared with 0.86 kg/day from P. flaccidum and 0.73 kg/day from Panicum virgatum.

### Technological Objective 3 .

New and improved cultural and management practices that increase forage crop and turfgrass seed yield, reduce production losses, and improve seed quality.

### Research Locations:

3611	Palmer, Alaska
3302	Lafayette, Indiana
7317	Stillwater, Oklahoma
5809	Corvallis, Oregon
5806	Prosser, Washington
5802	Pullman, Washington

### Selected Examples of Recent Progress:

Physiological response of Kentucky bluegrass to post-harvest residue burning - Pullman, WA. Completed research initiated in 1975 to determine the physiological response of Kentucky bluegrass to post-harvest residue burning that results in increased seed production and delays the age associated decline in seed yield. These data will be the first documentation to show that post-harvest residue burning increases yield primarily by reduction in thatch and the subsequent development of a greater number of large tillers in the autumn regrowth. This research also shows that tillers of Kentucky bluegrass must make adequate autumn regrowth to be capable of receiving the thermophoto-periodic stimulus for floral primordia induction.

Control of blind seed disease and ergot - Corvallis, OR. Field control of blind seed disease and ergot by one application of sodium azide in late April or early May was demonstrated. If sodium azide can be registered, chemical control of these diseases would be possible for the first time and could represent a substitute for field burning.

Successful conclusion of bermudagrass seed production investigations - Stillwater, OK. Cultural and management practices involving fertilization, timing of spring mow-back, and irrigation practices to manipulate plant physiological responses to environment have been established for bermudagrass seed production in Oklahoma. Management practices or agronomic techniques that are timely in regulating plant responses to environment, provided that seed production is being attempted with clones that have a high degree of self-fertility and are cross-compatible or both is the key to successful seed production. Until now, seed

production (yield) of bermudagrass was thought uneconomical in Oklahoma. Seed yields from the summer seed crops and from our best management plots have averaged 650, 843, 828, and 803 kg seed/ha for 1975, 1976, 1977, and 1978, respectively. Establishment of winter-hardy bermudagrass stands from (Syn-1) seed has considerable cost advantages over sprigging, has the advantage of being used easily in confined areas, such as home-sites, steep embankments, dams, and roadbanks. In addition seed availability of these strains offers the potential of aerial seeding of rocky hillsides, the production of reasonably high forage yields, quicker establishment on problem soil sites.

Components of seed yield - Lafayette, IN and Prosser, WA. Path coefficient analyses of seed yield components in red and white clover, orchardgrass, and Italian ryegrass revealed the actual contribution of each component to seed yield in the various species. Components studied included heads/m<sup>2</sup>, seeds/head, seed weight, florets/head, percent florets with seed, and seeds/floret. This knowledge will provide a selection tool assisting the plant breeder in improvement of seed yielding potential in these species.

Path coefficient analyses indicated the number of seeds/head to be of greater importance in determining red clover seed yield in midwest produced seed than found in western grown seed, and conversely, heads/m<sup>2</sup>, less important. The relative contributions of heads/m<sup>2</sup>, seeds/head, and seed weight was found to be 46, 44, and 10% in unclipped plots, and 61, 29, 10% in clipped plots. There was little variation in component response between plots seeded in wide or narrow drilled rows, wide or narrow checked hills, or broadcast plots. The results of this study indicate difficulty in accurately predicting component response in the western seed producing regions from component response in the midwest.

Grass forage yields not affected by long-term subfreezing seed storage - Prosser, WA. Seed of seven grass varieties stored in freezers for 12 to 15 years at about 5° F produced as much forage as did genetically identical fresh seed of the same varieties except for one seed lot of meadow fescue with poor seed germination before storage. It was concluded that forage yields would not be affected by long-term, sub-freezing, seed storage if the seed was of high quality when initially stored. These results, not previously documented, add important new information to research literature.

#### Technological Objective 4.

Turfgrass cultivars and genetic populations with increased pest resistance, tolerance to environmental stress, and improved agronomic characteristics.

#### Technological Objective 5:

Improved cultural and management practices for turfgrasses that reduce the costs of maintenance, increase ground cover value, provide greater persistence, and improve aesthetics.

Research Locations:

3611 Palmer, Alaska  
1108 Beltsville, Maryland

Selected Examples of Recent Progress:

Tall fescue with increased tolerance to acid soil conditions - Beltsville, MD. Tall fescue plants selected for tolerance to acid soil conditions were intercrossed. Progeny or seeds from the intercross yielded 24% more vegetation than commercially available varieties after 32 days growth in soil with a pH of 4.2. Large hectarages of soils are too acid for optimum plant growth. The conventional practice of liming the soil to some optimum level for plant growth on many sites is not economically feasible. Thus, an alternative or supplementary approach to liming to correct soil acidity problems may be to develop cultivars having greater tolerance to strongly acid soils. Tolerant varieties should perform better under adverse environmental conditions such as moisture stress.

Management practices significantly influence chinchbugs in red fescue - Beltsville, MD. Fewer chinchbugs occurred in red fescue maintained at 1 inch height of mowing than at 2 or 3 inches. Chinchbug infestations were influenced less by fertility and irrigation practices. Results indicate that maintenance practices, especially height of mowing, may be an effective control measure. Insect control by altering maintenance practices would reduce the need for insecticides.

# VARIETIES RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
Tifton 44 Bermudagrass	SEA-Georgia, & Georgia AES	Improved winter hardiness and forage quality.
Seralia '76 Sericea Lespedeza	SEA-Alabama, & Alabama & Georgia AES	Fine-stemmed, tall-growing variety resistant to most root-knot nematode species.
Interstate '76 Sericea Lespedeza	SEA-Alabama, & Alabama & Georgia AES	Fine-stemmed, dense, leafy variety resistant to most root-knot nematode species.

## NONCOMMERCIAL GERMPLASM RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
Alfalfa Germplasm: C-6	SEA-Colorado & Colorado AES	Selected for drought resistance.
MSE <sub>6</sub> SN <sub>3</sub> W <sub>3</sub> and MSF <sub>6</sub> SN <sub>3</sub> W <sub>3</sub>	SEA-Minnesota, Nevada, & Minnesota & Nevada AES	Resistant to stem nematode, bacteria wilt, spotted alfalfa aphid & pea aphid.
Nevada Syn YY	Sea-Nevada & Nevada, Oregon, Utah & Washington AES	Semi-dormant germplasm resistant to root-knot nematodes, stem nematode and spotted alfalfa aphid.
Washington SNI	SEA-Nevada, Washington, & Nevada & Washington AES	Resistant to stem nematode and bacterial wilt.
NMP-8	SEA-Minnesota, Nevada, & Minnesota & Nevada AES	Non-dormant germplasm resistant to anthracnose, phytophthora root rot, spotted alfalfa aphid & Fusarium wilt.
NMP-10	SEA-Minnesota, Nevada, & Minnesota & Nevada AES	Non-dormant germplasm resistant to anthracnose, phytophthora root rot, spotted alfalfa aphid and pea aphid.
Red Clover Germplasm: N-2	SEA-Nebraska, & Nebraska AES	Resistant to yellow clover aphid and pea aphid.

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## National Research Program 20110

### IMPROVED VEGETATION AND MANAGEMENT PRACTICES FOR RANGE

This National Research Program involves research to develop new and improved technology to increase productivity from improved vegetation and management practices for range; to conserve, protect, and improve our Nation's range resources; and to enhance the multiple use of those resources. A multidisciplinary team approach of both Federal and State researchers is dedicated to this effort.

NPS Contact: R. F Barnes

#### Technological Objective 1.

Acquire, describe, and evaluate new germplasm; and develop and test improved cultivars of grasses, legumes, shrubs, and forbs with increased ease of establishment, productivity, forage quality, persistence, improved seed qualities and tolerance to grazing, and with reduced losses from antiquality constituents, pests, and environmental hazards.

#### Research Locations:

5502	Tucson, Arizona
5602	Fort Collins, Colorado
5707	Dubois, Idaho
5708	Bozeman, Montana
5507	Las Cruces, New Mexico
3605	Mandan, North Dakota
7316	Woodward, Oklahoma
5810	Burns, Oregon
5702	Logan, Utah

#### Selected Examples of Recent Progress:

New evaluation procedure for range forage germplasm - Logan, UT. An active, coordinated program to evaluate new plant materials for use on a variety of rangeland conditions is in operation. The program coordinates the cooperative efforts of SEA-AR and university scientists, land management agencies, and ranchers in establishing, evaluating, and reporting pertinent data on the adaptation and potential use of newly created forage plants for grazing and conservation purposes. Study sites in the major range ecosystems of the intermountain area were located and cooperators selected. Ten lines of new plant materials were planted in 1978 at five locations. This evaluation program provides practical application for range plant breeding programs and will provide direction in developing new plants for use on range and pasture lands and mine spoils.

A new Triticum-Agropyron hybrid renews interest in "perennial wheat" - Logan, UT. Numerous hybrids have been made between annual wheat (Triticum) and perennial wheatgrass (Agropyron) to transfer genes from the wild grass species into cultivated wheat or to synthesize a new species. Almost all previous hybrids have involved either tall wheatgrass (A. elongatum) or intermediate wheatgrass (A. intermedium-trichophorum); and for the most part, results have been disappointing. Recently, Agropyron podperae (no common name) was hybridized with wheat. Fertility was restored to the sterile F<sub>1</sub> hybrid by treatment with colchicine. The amphiploid hybrid provides a new gene source for breeders working with Triticum-Agropyron hybrids.

New forage species being developed through wide hybridization - Logan, UT. More than 50 potentially new species of forage grasses have been synthesized by interspecific and intergeneric hybridization among Agropyron, Elymus, Sitanion, and Hordeum species. The F<sub>1</sub> hybrids are sterile, but fertility has been restored by chromosome doubling with colchicine. Unfortunately, fertility of the hybrid populations often declines in subsequent generations. In 1978, the most fertile and vigorous plants were selected from each population in an effort to stabilize or improve fertility while maintaining good vegetative vigor. Fertility differed widely among and within the various hybrid populations with E. canadensis X E. glaucus, E. canadensis X A. striatum, A. libanoticum X A. trachycaulum, E. canadensis X A. libanoticum, A. dasystachyum X A. caninum, A. fibrosum X A. trachycaulum amphiploids being the most fertile. Several of the amphiploids have promise of useful forage grasses.

Potential new species for semi-arid rangelands - Logan, UT. A breeding population developed from the bluebunch wheatgrass (Agropyron spicatum) X quackgrass (A. repens) hybrid is being refined and tested over a series of representative environmental and management conditions. Seed fertility of hybrid plants in the F<sub>7</sub> generation is comparable to the parental species. Results indicate that the drought hardiness and plant type (bunch habit) of bluebunch wheatgrass have been successfully combined with the general vigor and yield potential of quackgrass. A seed increase program has been initiated.

Isolate and evaluate germplasm for photosynthetic efficiency of blue panicgrass - Tucson, AZ. Techniques and facilities were established to isolate and evaluate blue panicgrass germplasm sources by recurrent selection through succeeding generations to provide genotypes with increased photosynthetic rates. The potential is for increased food production by solar energy through forage -- meat and milk -- as major input for society.

Drought-resistant alfalfa germplasm pool developed - Fort Collins, CO, and Mandan, ND. This pool traces to a collection of drought-resistant selections made by A. C. Dillman at Belle Fourche, SD, between 1910 and 1914 and to a collection assembled by G. A. Rogler at Mandan, ND. Both

collections trace directly to introductions made by N. E. Hansen in the early 1900's. Open-pollinated seed from drought-resistant plants was produced in South Dakota and was stored in an unheated, uninsulated building at Mandan, ND, from 1915 to 1971. The introductions were from the Samara Province, Tomsk Province, and the Semipalatinsk region of the U.S.S.R. Known cultivars in the collection were 'Cossack,' 'Canadian Variegated,' 'Cherno,' and 'Sibturk.' This pool will serve as source material for the development of drought-resistant cultivars of alfalfa.

Superior seedling drought resistance in dryland alfalfa - Logan, UT.

The world's collection of alfalfa from Ames, Iowa, has been screened for superior seedling drought resistance using previously developed laboratory and greenhouse techniques. Alfalfa lines with superior ability to emerge under drought stress and also to recover after a drought exposure were identified. These selected individuals along with their unselected counterparts have been planted in the field for seed increase. Seed from the selected and unselected populations will be run through the laboratory and greenhouse screening procedures as well as planted on a droughty field site to detect genetic advancement for enhanced seedling response under drought.

Biological nitrogen fixation on semi-arid range sites - Logan, UT.

Thirty-eight introduced and native legume species from six representative range sites were assayed for field nitrogen-fixing capability during mid-summer. Medicago sativa was able to fix nitrogen even during the highly stressed mid-portion of the Intermountain West growing season. This strongly suggests that given more favorable growing conditions in April, May, or June biological nitrogen fixation on semi-arid rangelands could, at least in some circumstances, be significant.

Search for bloat-safe alfalfa continued - Logan, UT. Approximately 14,500 alfalfa plants were tested for the presence of condensed tannins. All results were negative and tannins cannot therefore yet be used to breed alfalfa populations which may be grazed by ruminants without risk of bloat. If tannin producing genes can be found in the annual Medicago species or induced in alfalfa by mutagens, such a bloat-safe alfalfa cultivar might be possible.

Breeding program for Cicer Milkvetch improves seedling emergence - Fort Collins, CO. One cycle of recurrent selection for rapid seedling growth at a 20C day/15C night temperature regime in environmental chambers was more effective for improving seedling vigor than selection at a 25C day/20C night treatment. Forty-four percent of the progenies selected at 20/15C were significantly higher than the reference progeny for seedling emergence in the field compared to 15 percent of the progenies selected at 25/20C.

## Technological Objective 2.

Develop range improvement practices for increasing productivity of rangeland.

### Research Locations:

5502	Tucson, Arizona
5602	Fort Collins, Colorado
5707	Dubois, Idaho
5708	Bozeman, Montana
5709	Miles City, Montana
5208	Reno, Nevada
5507	Las Cruces, New Mexico
3605	Mandan, North Dakota
7316	Woodward, Oklahoma
5810	Burns, Oregon
7307	Temple, Texas
5609	Cheyenne, Wyoming

### Selected Examples of Recent Progress:

Plant responses to enhanced solar UV-B radiation - Las Cruces, NM. The ontogenetic course of photosynthesis of Curcubita pepo exposed to UV-B radiation doses was determined. During the periods of maximum photosynthetic activity (leaf age of 4 to 8 days), photosynthetic rates were reduced by 18 and 42% when exposed to UV-B radiation simulating 10 and 40% ozone reductions, respectively. Leaf areas were reduced by 11% at full leaf expansion only when the plants were exposed to a level of solar UV-B radiation equal to a 40% ozone reduction. The reduced leaf area for photosynthesis plus depressed photosynthetic rates would reduce the total plant reserves for both leaf initiation and growth, as well as fruit production.

Photosynthesis and respiration of fourwing saltbush - Las Cruces, NM. An in-situ root respiration apparatus was developed for simultaneous measurements of total plant CO<sub>2</sub> gains (photosynthesis) and losses (root respiration). Intensive measurements of the shrub, fourwing saltbush, showed that CO<sub>2</sub> losses through root respiration activity is governed by photosynthetic rates. In addition, high soil temperatures increase root respiration rates. Thus, extended periods of limited soil moisture that would restrict photosynthetic activity and high soil temperatures that accelerate root respiration rates, could significantly deplete total plant reserves and limit seasonal productivity.

Light penetration into alfalfa canopies - Bozeman, MT. Studies of light penetration into alfalfa canopies showed that multifoliate leaves allow the same light penetration as trifoliate. However, large-leaved alfalfas allow more light to penetrate to canopies than small-leaved alfalfas at the same LAI. This work will be important in future selection of alfalfas.

Forage plants for revegetation - Las Cruces, NM. Prolonged spring droughts, erratic rainfall, and relatively cold winters greatly restrict the number of improved forage grasses which can be successfully planted in the Southwest. Screening of all available forage varieties in adaptation nurseries indicates that Lehmann lovegrass L-38 and NM 317, Ermelo lovegrass and Sonora black grama are best suited to southern New Mexico conditions. Kleingrass has been a surprising performer and is worthy of field-scale tests. Recently developed lovegrass hybrids also show potential in ability to survive and desirable forage characteristics.

Winterfat found to be adapted to range sites in Northern Arizona - Tucson, AZ. Winterfat, a nutritious, palatable shrub was established by transplanting at five of six sites in northern Arizona. It became established and is spreading at Red Mountain, Indian Flat, Drake, Hart Ranch, and Cosnino. This plant could be used to revegetate rangeland sites by transplanting only on portions of the more favorable sites. After becoming established, this plant produces seed and spreads through natural means to the rest of the favorable sites and into the less favorable sites. This information is important because it indicates a method for revegetating rangelands with minimal cost and little disturbance of the soil.

Alfalfa seed size - Bozeman, MT. Research with alfalfa seed size showed that there is no advantage to sizing seeds, in terms of reducing seeding rate. Seeding rates as low as two pounds per acre gave excellent stands.

Methods developed for sodding blue grama - Fort Collins, CO. Blue grama has been difficult to establish by direct seeding but small areas can be established readily from sod. For a successful operation, we have found that (1) sodding should be done between mid-May and mid-July, (2) the sod should be wet when cut, and (3) the sodded area should be watered after laying. These recommendations insure that new adventitious roots will develop and a large percentage of the tillers will survive.

Thinning blue grama reduces drought damage - Fort Collins, CO. Thinning a native stand of blue grama by chemically killing strips 30 cm wide while leaving undisturbed strips 15 cm wide has increased seed yield, increased amount and availability of winter forage, and reduced the damaging effects of drought. This practice may become a practical method for improving blue grama rangeland.

Punch planting - an improved seeding method - Temple, TX. Punch planting is a new way to plant range and grassland plants. In punch planting the seed is placed in the bottom of a small diameter hole in the soil which remains open until the plant emerges and fills the hole. Punch planting places the seed much deeper in the soil than normal planting and thus keeps it wet longer. Under dry conditions, which are normal in the Great Plains, punch planting produced satisfactory stands of 5 range grasses, but conventional planting methods produced few plants. This new planting method may greatly improve the success of grass seeding.

Need for topsoil for revegetating coal stripmine spoils demonstrated - Fort Collins, CO. Greenhouse studies have shown that the deeper the layer of topsoil that is placed over coal stripmine spoils (up to 46 cm in this study), the better the growth of seeded grass, both top growth and roots. Nitrogen fertilizer improved root and top growth on both spoil and topsoil. These results show that topsoil is needed for good growth of seeded grasses on coal stripmine areas and N fertilizer also can be a help.

Identification and characterization of soil surface types on rangelands aid in range seeding - Reno, NV. Coppice and interspace soils with intermediate types on Intermountain rangelands provide greatly differing soil surfaces in regard to water penetration, fertility level, and seedling emergence. Interspace soils (between shrubs) often have very hard surfaces that are infertile and almost impossible for grass seedlings to penetrate. Coppice soils (under shrubs) are friable, have high organic content, and provide excellent media for grass seedling emergence and plant growth. Identification of these soil-surface types and their relative areas are important in artificial revegetation and natural revegetation under livestock grazing systems on rangelands.

Improving ranges infested with creosotebush - Las Cruces, NM. A site dominated by creosotebush rootplowed and seeded in 1-1 and 2-1 water harvesting strips yielded 2,817 kg/ha of total herbage with 1,829 kg/ha being the seeded perennial grasses. Infiltration rates were significantly higher on a 1972 rootplow treated creosotebush site than on a 1976 rootplow treatment indicating increased soil pore formation in the 1972 treatment.

Juniper can be controlled by spot treatment with Tebuthiuron - Burns, OR. Good control of Juniper less than 6 feet tall was obtained with spot treatment of Tebuthiuron; this could be a viable solution for controlling invading Juniper onto prime brush range. However, when Tebuthiuron pellets were broadcast for Juniper control, high mortality of the herbaceous understory occurred. This research indicates that the carrying capacity of Great Basin ranges can be increased by control of this competing species.

Imprinting, seeding, and herbicide treatments increase forage species diversity in creosotebush community - Tucson, AZ. Tebuthiuron treatments were applied to control creosotebush. Bushmuhly and three awn species present on the site increased after control of the creosotebush, but total dry matter production was decreased by land imprinting and seeding. This information is important because it shows that depleted creosotebush sites can be revegetated through a system of herbicide control and reseeding.

Modification of commercial ground sprayers provide ranchers with efficient equipment for brush control - Reno, NV. Commercial ground sprayers were modified by strengthening booms, supports and other parts that receive extremely hard use under rangeland conditions. Boom height adjustments were changed to accommodate spraying at heights above brush. A dye marker system was also included on the sprayers to identify spray swaths on rough terrain. These modifications enable spraying of brush on rangelands by individual ranchers where aerial application would not be feasible.

Irrigated pasture mixtures - Bozeman, MT. An evaluation of twenty pasture mixtures showed that of the grasses studied, Regar Meadow brome grass yielded 0.4 ton/A more forage than any other grass when seeded in a grass-legume mixture under irrigation. This species is expected to make a major impact on forage production in the West's 5 million acres of irrigated pastures.

Other species in order of declining yield were Manchur smooth brome grass, Troy Kentucky bluegrass, and Chinook orchardgrass. Of the legumes studied, alfalfa contributed most and birdsfoot trefoil least to mixture yield.

### Technological Objective 3.

Develop grazing (forage-livestock) management systems which convert range forage more efficiently to animal products and are consistent with improvement, conservation, and multiple use of range ecosystems.

### Research Locations:

5602	Fort Collins, Colorado
5707	Dubois, Idaho
5709	Miles City, Montana
5208	Reno, Nevada
5507	Las Cruces, New Mexico
3605	Mandan, North Dakota
7316	Woodward, Oklahoma
5810	Burns, Oregon
5609	Cheyenne, Wyoming

### Selected Examples of Recent Progress:

Electronic weighing of livestock - Las Cruces, NM. Animal weights, identification number, date and time can be entered on cassette tape in a matter of seconds. Data can be obtained at remote locations since the electronics will operate on 12V DC or 120V AC. This weighing system reduces labor and virtually eliminates transposition errors which can occur during manual entry of data into storage files.

Supplemental feed for cows on arid rangeland - Las Cruces, NM. Range cows were grazed together. One third received no supplemental feed, one third received cottonseed meal (CSM); and one third received pellets partially made from sewage sludge (RS 2). Both CSM and RS 2 supplemented range forage in the dry spring and early summer at the rate of .22 kg/head/day. Feeding RS 2 had no measurable effects on the blood or liver contents of a number of elements. Feeding RS 2 increased milk content of Zn over cows fed CSM and no supplement. The milk from all cows was deficient in Cu and Mn, and possibly Zn. Supplementation of cows with CSM and RS 2 increased calf weights at weaning 11% and 7%, respectively, over the unsupplemented controls. The response of cows and calves to CSM and RS 2 may be due in part to supplemental minerals, as well as protein and energy.

Native range - complementary forage beef production system - Woodward, OK. Hybrid cattle (Brangus bulls (5/8 Angus, 3/8 Brahman) on 1/2 Angus-1/2 Hereford cows yielding 9/16 Angus, 4/16 Hereford, 3/16 Brahman calves) coupled with hybrid forages (pearl millet for summer and wheat and rye pasture for winter and spring) in complement to native range gives an extra 200 to 250 pounds more gain per cow than typical native range. One acre of the farmed-forages and 11 acres of native range was used in this system compared to 17 acres of native range for a typical ranch operation. Cost of farmed-forages was about \$35/acre resulting in the cost for an additional pound of gain of 20 cents with net returns per animal unit ranging from \$140 to \$175.

Forage competition between wild horses or cattle and deer is minimal - Burns, OR. Similarity indices of plant species in the diets of wild horses and of cattle were high but diet similarity of both compared with that found in diets of deer was low. Only when snow depth and cold winds forced deer and horses to south exposed and wind swept ridges did a partial diet overlap occur and this was with Phlox spp. which at those times resulted in 10 to 50% of the diet. Results of this study indicate that deer populations could be managed on eastern Oregon ranges without a major conflict with livestock production.

Consumption of fourwing saltbush - Fort Collins, CO. Diets of cattle grazing shortgrass prairie containing varying amounts of fourwing saltbush were analyzed. Fourwing saltbush contributed an appreciable portion of diets (16%) during the spring, summer, and fall and a much larger portion (31%) during winter, on pastures containing considerable amounts of saltbush. This supports the value ranchers place on fourwing saltbush, especially for winter pasture.

Response of livestock gain to stocking rate on range - Cheyenne, WY. Under range conditions, gain per grazing animal is very nearly approximated by a model in which gain remains constant below a critical stocking rate, and decreases linearly as stocking rate increases above the critical rate. This model conflicts with the model in which, when forage supply is limiting, gain increases linearly with increasing forage per animal or decreases

hyperbolically with its inverse, animals per unit of forage, which is synonymous with grazing pressure or stocking rate. Although the latter model is valid at any given time, it is not valid for an entire grazing season on rangeland. Changes in forage growth rate, availability, and quality, combined with changes in nutritional requirements of the grazing animal, produce constant changes in the shape of the response curve and the value of the critical stocking rate and a linear decrease thereafter. This model can be used to determine the economically optimum stocking rate, or for economic comparisons of range improvement practices.

Modeling beef production from soil-plant-animal systems in the Central High Plains - Cheyenne, WY. Short-term and long-term curves showing response of average daily gain to stocking rate are quite different. At any point in time, gain declines hyperbolically as stocking rate increases above the critical rate, but over the season the decline is linear. It was shown that the seasonal curve represents the arithmetic mean of a family of instantaneous curves, in which both critical stocking rate and gain below the critical rate decline during the season with decline in forage quality and availability. Gain of suckling calves was shown to follow the same response curve as gain of mature grazing animals.

VARIETIES RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
Kuivato Lehmann Lovegrass	SEA-Arizona, SCS, and Arizona AES	Developed for tolerance under stress environments of the Southwest under 1400 m elevation and 25 to 30 cm annual precipitation.
Puhuima Lehmann Lovegrass	SEA-Arizona, SCS, and Arizona AES	Developed for tolerance under stress environments of the Southwest under 1400 m elevation and 30 to 35 cm annual precipitation.

NON COMMERCIAL GERMPLASM RELEASED

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
Cicer Milkvetch Germplasm Pools: C-4 and C-5	SEA-Colorado and Colorado AES	Selected for seed weight and mature plant vigor.

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## National Research Program 20160

### INTRODUCTION, CLASSIFICATION, MAINTENANCE, EVALUATION AND DOCUMENTATION OF PLANT GERMPLASM

Research is directed to provide breeders and other applied plant scientists with the genetic resources needed for improving crop plants in terms of their reaction to environmental stresses such as insect and disease pests, adverse weather, and moisture supplies, and in terms of compositional characteristics and nutritional factors. It also provides for a continuing evaluation of new plant resources that have the potential of becoming viable new crops which can provide raw materials needed for changing industrial and medical technologies or to meet national requirements for strategic materials.

NPS Contact: Quentin Jones

#### Technological Objective 1.

Expanded collections and improved maintenance, evaluation, and distribution of plant germplasm as sources of useful genetic material to improve existing crops and developing new crops.

#### Research Locations:

3611	Palmer, Alaska
5102	Indio, California
0709	Boulder, Colorado
5602	Fort Collins, Colorado
1211	Washington, D.C.
7616	Miami, Florida
7707	Experiment, Georgia
7705	Savannah, Georgia
3408	Ames, Iowa
1108	Beltsville, Maryland
1205	Glenn Dale, New York
1308	Geneva, New York
7617	Mayaguez, Puerto Rico
5802	Pullman, Washington
3509	Madison, Wisconsin

#### Selected Examples of Recent Progress:

Clonal repository, date palms - Indio, CA. The date repository now comprises three acres. In 1978, the advanced backcrossed and/or hybrid males from the 1966-71 breeding program were moved into the repository.

Seed viability and storage research - Fort Collins, CO. Damage to sesame seed caused by immersion in liquid nitrogen and subsequent rewarming was minimized by reducing seed moisture to less than 10 percent before cooling

at -1C/min. or to between 4 and 8 percent before cooling to -200 C/min. Maximum safe moisture content for seed subjected to storage in liquid nitrogen was found to be 10 percent for sesame and 17 to 18 percent for sorghum.

Three of 22 chlorophyll deficient isolines of pearl millet showed a significant decrease in storage life of the homozygous recessive genotypes as compared to the normal phenotypes. Isolines for various nonlethal dominant and recessive genes also showed significant differences in rate of deterioration among isolines.

Distribution of plant introductions - Miami, FL. A total of 2,951 plant introductions were distributed to 391 cooperators in 18 countries.

Peppers resistant to tobacco mosaic virus - Experiment, GA. An additional 1,725 pepper PI's (Plant Introductions) were screened for resistance to TMV. Fifty-five had no systemic symptoms of infection and the virus was not recovered from inoculated plants. PI's 159236 and 257047 of Capsicum annuum appear to be the most promising for immediate use by plant breeders.

Field resistance of watermelon PI's to race 2 anthracnose - Experiment, GA. PI's 189225, 271775, 271778, and 299379 were resistant in field tests in Georgia, Alabama, and South Carolina, and in a greenhouse test. Resistance was expressed as significantly less defoliation and significantly fewer fruit lesions. Anthracnose causes an estimated \$4,700,000 annual loss in the farm value of watermelons in the United States.

Plant introduction germplasm used in varietal releases - Experiment, GA. PI 248999 was used in the development of the newly released Okra cultivar 'Lee'. PI 118457 was used in the new peanut variety 'Florigrass'. PI's 299993, 299994, and 299995 were used in the development of the cultivars 'Redalta', 'Greenalta', and 'Begalta' of the forage grass Hemarthria altissima.

Plant introductions that have made important contributions to plant breeding programs and to U.S. Agriculture in 1978 - Ames, IA.

### *Alfalfa*

Two alfalfa introductions were used in the stem nematode resistance germplasm release, Washington SNI, released by the USDA/SEA and the Nevada and Washington SAES's. PI 279958 with stem nematode resistance from Turkey was used via the WN-S-1 parental line and the stem nematode resistant PI 141462 from Iran was used via the WH-S-3 parental line.

A new alfalfa weevil resistance mechanism was discovered in PI 247790 from Peru by scientists at Purdue University. "A portion of the weevil larvae reared on this introduction convulsed, dehydrated and died before pupation. One clone produced up to 20 percent convulsing larvae and 40 percent mortality. Due to the large degree of variability for this trait in PI 247790, it should be possible to increase this type of antibiosis through selection." (Crop Sci. 18(2):208)

### *Beans*

PI 181954 was found to have a high tolerance (hypersensitive leaf reaction and no systemic chlorosis in leaves) to a new virulent (Nebraska isolate) strain of halo blight (Pseudomonas phaseolicola). GN Nebraska #1 selection 27, resistant to race 1 and 2, was susceptible to this new strain.

PI 255960 report based on F<sub>3</sub> data. The high ovule number (9-10/pod) of this PI line is controlled primarily by a single major gene with additive effects. The high ovule was found to be associated with purple flowers, colored seeds and late maturity in the F<sub>2</sub>.

It was found that the delayed flowering (lateness) of PI 207262 was due to a response of long days x high temperature, and was controlled by a single recessive gene.

### *Canarygrass*

PI 170622, Phalaris canariensis, from Turkey was used along with caryopses of 5 other cultivars in an evaluation of the potential of P. canariensis for food purposes. PI 170622 did not differ markedly from the others in chemical composition. However, as a species, P. canariensis caryopses has a total amino acid concentration of 19.25% and a N to protein conversion factor of 6.71. Its N-to-protein conversion factor was the highest reported for any crop. Canarygrass caryopses had higher concentrations of all eight essential amino acids than did those reported for wheat or corn caryopses. Annual canarygrass is a potential food grain crop.

### *Corn*

PI 251934, the cultivar 'Chernovitskaya-21' from USSR, was used in a corn hybrid released in Minnesota for its earliness and multiple eared tendency. Other favorable reports on its performance were received from Minnesota and Canada. However, it did not perform well at Lincoln, Nebraska in 1977, which was an unusually hot, dry year. The report from Lincoln stated that the accession grew quite well and flowered very early, as expected. Pollen production was excellent and silks emerged satisfactorily but the seed set was very poor. The accession evidently lacks heat and drouth tolerance because the nursery was irrigated. Therefore, one might expect it to perform better under cool summer conditions than under warm conditions.

Previous studies on PI 217413, Zapalote Chico corn, at the University of Missouri showed that it had resistance to corn earworm (Heliothis zea). The resistance was due to a chemical factor in the silks. Recently, Dr. Tony Waiss and his staff at the USDA, Western Regional Research Center, located the resistance factor and named it Maysin. Maysin is a flavone glucoside. When incorporated in diets, it severely retards earworm larvae growth and increases mortality. Studies are in progress at the University of Missouri to study the inheritance of Maysin synthesis.

Visual cob inspection of the following corn plant introductions indicated that these four had desirable cob characteristics, particularly the "wood" content for the Missouri pipe corn program: 172335 'Silvermine'; 221895 'Dill White Dent'; 314844 'Mammoth White Pearl'; and 363067 'White Dent'.

Additional sources of monogenic chlorotic-lesion resistance to Helminthosporium turcicum were found in corn PI's at the University of Illinois. They are 190081, Guatemala; 218167, New Mexico; 186221 and 186224, Argentina; 186231, Uruguay; 217415 'Drought Proof', West Virginia; 217461 'King Philip', New York; 166700, Argentina; 213713 'Mortgage Lifter'; and 221866 'Boone Co. White', Missouri.

### *Tomatoes*

Two tomato introductions, 213189 from Greece and 298633 from the USSR, were among the parents used in the 'Oregon Cherry' tomato variety released in 1978.

A selection from a small fruited tomato species, PI 365899 had the highest level of resistance to leaf spot caused by Septoria lycopersici of the 34 red-fruited PI entries screened. This selection has been designated PI 422397. Three other introductions, 111406, 111407, and 205014 showed resistance.

The tomato PI 272636 is a recognized source of resistance to anthracnose. It was used as a resistant check for evaluating breeding lines for anthracnose resistance. It was also used by Del Monte plant breeders, resulting in an anthracnose-tolerant tomato variety.

In 1973-1976, 4,050 accessions of the world collection of tomatoes were screened for heat tolerance based on fruit setting at high temperatures at the Asian Vegetable Research and Development Center, Taiwan. A high percentage of the 4,050 accessions was derived from the world collection at Ames, Iowa. The following showed high levels of heat tolerance during the evaluation period: 365914, Ecuador; 273445 'Nagcarlan', Philippines; 365916 and 365917, Ecuador; 136452, Canada; 203232, South Africa, and 290856, Texas. PI 365917 was used as a heat tolerant check.

The tomato, PI 134417 (Lycopersicon hirsutum f. glabratum) from Ecuador is highly resistant to the tobacco hornworm, Manduca sexta, as manifested by reduction in larvae survival and weight gained by survivors over a 72 hour period.

### *Ornamentals*

PI's 420323 to 420327, Betula maximowicziana, from Hokkaido, Japan, is highly resistant to bronze birch borer and will be an excellent replacement for susceptible species such as B. papyrifera, B. pendula, and white barked birches.

Crabapple cultivars 'Silver Moon' and 'Tschonoski' have been reported to be highly resistant to scab and rust under Kansas growing conditions.

Insect evaluations of agronomic and horticultural crop introductions - Ames, IA. The evaluation of the corn collection for resistance to sheath-collar feeding by 2nd-generation European corn borer has been completed. Introductions that showed resistance to this type of feeding were further evaluated for resistance to stalk tunneling. Introductions that were resistant to both sheath-collar feeding and stalk tunneling were 162927, 186209, 209135, 218191, 226685, 317328, 317329, 317330, 349256, and 406133. The source of original seed of six of these introductions is either Central or South America, thought to be the center of the origin of corn.

The entire corn collection was evaluated for resistance to black cutworm. Evaluations were made on the basis of leaf feeding on seedling corn plants by 3rd instar larvae. No introductions were resistant although pop corns were extremely susceptible.

A technique has been developed so that much time can be saved in infesting corn with cutworms. Larvae can be scattered on the soil surface in flats rather than being placed on individual corn plants with a small brush, provided plants are very small at the time of infestation. This technique in no way deviates from field conditions inasmuch as very small corn plants are frequently damaged under field conditions.

The entire sunflower collection has been evaluated for resistance to sunflower moth. Resistance was identified in 13 introductions, the most resistant being 172906, 204578, and 380569. Other resistant introductions include 162453, 171656, 171657, 176974, 226466, 343809, 369357, 369358, 380562, and 380563. Infestations were somewhat lower in small-headed wild type sunflowers than in those with large single heads. Infestation and damage was also less in taller, late flowering introductions. Delayed planting of sunflowers reduced sunflower moth significantly.

Disease evaluation of agronomic and horticultural crop introductions - Ames, IA. Twenty-four tomato lines showed promise of resistance to fruit rot in 1978 and will be included in the 1979 tests. PI 367968, a carry over from 1977, looked good again in 1978. Four others, 367952, 378994, 379404, and 387854 were outstanding in the 1978 test, but need further evaluation.

Eleven of the cucumber lines tested had no rot in 1978. They will be retested in 1979, along with 7 others from the 1978 test.

Six of 140 lines in a replicated, inoculated test had resistance as good as, or better than, the stalk rot resistant checks H5338 and AES704. The six lines are: 171921, 186189, 186198, 194384, 406199, and 406218. Of the same 140 lines in a rust nursery, nine showed good levels of polygenic resistance: 162701, 163597, 172328, 194387, 194388, 194389, 196127, 196128, and 196129. Of these nine, 196127 seemed to have the highest level of resistance, scoring less than 1 on a 0-5 scale, where 0 - immune, 5 - severe rust.

Twenty-four tomato lines were used in a 4-replicated field test near Muscatine, Iowa; 4 pi lines: 11406, 127814, 193413, and 204999, and a breeding line, #45-548, showed resistance to Septoria leafspot development.

RNA and viruses - Glenn Dale, MD. Primary research effort has been on a new phenomenon in plant virology - an infectious ribonucleic acid that is associated with but not part of cucumber mosaic virus. Some very significant observations were made during 1978 -- primarily that this RNA is able to regulate disease expression in several important crops. This RNA is produced only when CMV is in the plant with it. In some crops it permits the CMV to kill the crop (tomato). CMV alone does not ordinarily kill tomatoes. In other cases it protects the crop from the usual disease that CMV causes, and we see essentially healthy plants resulting (tobasco pepper). We now know that this CARNA 5 decreases or increases the usual affects of CMV in several other crops - cucumber, pumpkin, corn, lima beans, etc. In spite of many experiments, the question on the origin of CARNA 5 remains unanswered. We know it, like CMV, is aphid transmissible. We also know that cultures of CMV from 10 places in the U.S. support CARNA 5.

Pear seedling resistance to pear psylla - Geneva, NY. Using the laboratory screening method, two cultivars of pear (Seckel and Dayeune Gris) were susceptible. PI 10260 was resistant. Using the laboratory screening method, the two cultivars and PI 10311 were found susceptible. Two numbers, PI 10260-61, were resistant.

Resistance to flea beetles in cabbage - Geneva, NY. Forty-five cabbage introductions were screened for tolerance or resistance to flea beetles but none were more resistant than the standard cultivar (Roundup).

Screening alfalfa introductions for tolerance or resistance to the potato leafhopper - Geneva, NY. Two seasons of field testing revealed that certain alfalfa introductions (listed below) had 50 to 55% less damage than the standard cultivars. The peak leafhopper infestation was in mid-July. Later in mid-August (beyond peak infestation) they showed 28% less damage than the standard cultivars. The numbered introductions are: M. falcata: PI 172984, 235021, 251688-89, 251830, 258750, 258754, and 263154. Medicago pironae displayed the highest degree of resistance by showing 52% less damage than the standards at mid-August. All resistant introductions have smaller leaves, more slender stems, prostrate habit, and slower re-growth after cutting. Resistance appears to be associated with ovipositional non-preference.

SUMMARY OF PLANT GERMPLASM  
INTRODUCTION AND USE  
1978

Principal Centers:

Office of Plant Introduction,  
Beltsville, MD  
Foreign Exchange

Introduced: 10,656      Sent Abroad: 221,976

National Seed Storage Lab.,  
Fort Collins, CO  
Base Collection, Long-term  
Storage

In: 2,513      To Users: 2,269

Working (Active) Collections:

Regional Plant Introduction  
Station, Experiment, GA

In: 2,513      To Users: 26,068

Regional Plant Introduction  
Station, Ames, IA

In: 920      To Users: 10,350

Regional Plant Introduction  
Station, Geneva, NY

In: 1,318      To Users: 6,201

Regional Plant Introduction  
Station, Pullman, WA

In: 1,380      To Users: 14,513

Small Grains Collection,  
Beltsville, MD

In: 2,285      To Users: 204,436

## Technological Objective 2

New and improved knowledge of the chemical, biological, and agronomic potentials of selected plant species as new crop sources of industrial oils, waxes, gums, fibers, of food and feed proteins, and licit and illicit narcotic drugs and other medicinals.

### Research Locations:

5502	Flagstaff, Arizona
7705	Savannah, Georgia
0710	Bloomington, Indiana
3102	Peoria, Illinois
3408	Ames, Iowa
0709	Rehovot, Israel
1103	Beltsville, Maryland
1108	Beltsville, Maryland
0203	Islamabad, Pakistan
1402	Philadelphia, Pennsylvania
7617	Mayaguez, Puerto Rico
0709	Chiang Mai, Thailand
0709	Ankara, Turkey
5502	Pullman, Washington

### Selected Examples of Recent Progress:

Effects of honey bee pollination on *Papaver bracteatum* - Flagstaff, AZ. Percentage is not affected by bee pollination but capsule size and seed production are improved with pollination.

Evaluation of herbicides for use with kenaf - Savannah, GA. Profluralin mixed with Prometryn produced the highest kenaf yields. Trifluralin was almost as effective. Kenaf is highly sensitive to Bifenox.

Structure of new alkaloids determined - Peoria, IL. Two new alkaloids which have shown antitumor activity in the Cancer Program are sesbanine from *Sesbania drummondii* and cephalomannine from *Cephalotaxus mannii*. The complete structure of these alkaloids has been determined.

Screening of plants for preliminary anticancer activity - Beltsville, MD. During the year, 1,300 plant samples of three pounds each were procured for initial screening. Procurement of 60 re-collections of plants with confirmed activity was also accomplished (21,000 pounds in all), while very large amounts of six species were collected to provide enough extract for preclinical and clinical testing of active ingredients.

Biosynthesis of phenanthrene alkaloids in *Papaver somniferum* - Philadelphia, PA. Polyphenol oxidase plays a significant role in regulating the biosynthesis of morphine, codeine, and thebaine in *Papaver somniferum*. Inhibitors of polyphenol

oxidase activity disrupt alkaloid metabolism in intact plants and excised capsules and can significantly decrease the phenanthrene alkaloid content of treated capsules.

Anagyrine in Lupinus spp. - Pullman, WA. Accessions of L. alpestris, L. argenteus, L. candatris, L. erectus, L. evermansii, L. leucophyllos, L. montegenus, L. polyphyllus, and L. sericeus showed anagyrine levels in foliage of 1.5 g/kg to 16.9 g/kg, varying during the growing season. Anagyrine values in seed ranged from 5.7 g/kg to 36.0 g/kg.

### Technological Objective 3.

Increased understanding of the taxonomic relationships, geographical and ecological distribution, and centers of diversity of crop plants and their wild relatives to promote the systematic assembly of germ-plasm for crop improvement.

### Research Locations:

1108 Beltsville, Maryland  
1211 Washington, D.C.

### Selected Examples of Recent Progress:

Additional aid to identification of rice, wild rice, and relatives - Beltsville, MD. Scanning electron microscopy of the surface of leaves and hulls of rice, wild rice, and two related genera revealed morphological characteristics useful in the identification and classification of these economically important grasses.

Plant nomenclature file computerized - Beltsville, MD. This file of about 40,000 scientific names of plants introduced since 1898 is the basis for Latin names used in publications and reports by USDA scientists and others. The first stage of computerization was completed which will greatly increase efficiency in correcting the file and adding the approximately 500 new names incorporated each year.

Uniformity of names of seed in national and international commerce achieved - Beltsville, MD. Scientific and common names were standardized so that nomenclature of these economic plants in the U.S. Federal Seed Act, Rules for Association of Official Seed Analysts, and International Seed Testing Association will be uniform.

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## National Research Program 20170

### PHYSIOLOGICAL AND BIOCHEMICAL TECHNOLOGY TO IMPROVE CROP PRODUCTION

National Research Program 20170 involves research elucidating the basic function of plants at the physiological and biochemical level. New data yielded by this research will establish advanced agricultural technology focused on field and horticultural crops. Major emphases of this National Research Program are:

1. Improve the photosynthetic capability, photosynthetic efficiency, translocation, metabolism, and biological conversion of solar energy by plants.
2. Develop improved efficiency of nitrogen fixation and the absorption, translocation, and utilization of nutrients.
3. Improve crop production under environmental stress and reduce stress damage to plants.
4. Improve technologies for understanding water relations, seed germination, growth regulation, flowering, fruiting, and photoperiod as a base for using molecular biology to increase crop production efficiency.

NPS Contact: Gerald G. Still

#### Technological Objective 1.

Improve biological conversion of solar energy for increased crop production by increasing the efficiency of photosynthesis, translocation, and associated metabolism.

#### Research Locations:

7902	Athens, Georgia
3102	Peoria, Illinois
3311	Urbana, Illinois
1109	Beltsville, Maryland
7502	Mississippi State, Mississippi
7802	Raleigh, North Carolina

#### Selected Examples of Recent Progress:

Studies concerning the regulation of synthesis of RuBP carboxylase - Athens, GA. Large and small subunits of RuBP carboxylase are being purified from Euglena and corn. Antibody will be obtained once sufficient quantities have been purified. Immunochemical techniques will be worked out in order to answer some basic questions regarding RuBP

carboxylase synthesis. A second project involving wide crosses has resulted in the production of an interspecific hybrid between pearl millet and fountaingrass.

Photosynthesis in flashing light - Peoria, IL. A method involving light flashes was discovered to detect the flow of electrons between the oxygen producing and carbon fixing reaction centers in the green chloroplasts of plant material. The detected signals were generated during illumination with light flashes a few millionths-of-a-second long. Signals were shown to originate specifically from the carbon fixing reaction center and were due to the generation of a form of oxygen called superoxide ( $O_2$ ). Also, this method can be used to alter the charge state of the electron carriers between the oxygen producing and carbon fixing reaction centers. Out of such basic studies comes new concepts for increasing photosynthetic efficiency and for improving crop yields.

Photosynthesis in soybeans - Urbana, IL. Substantial increases in several parameters of soybean leaves were found to occur at the onset of reproductive growth, and these increases coincide with a marked increase in canopy photosynthesis. The parameters measured include specific leaf weight, soluble protein, and the carboxylating enzyme. An understanding of the mechanism which leads to increased synthesis of the photosynthetic machinery may permit manipulation of photosynthetic capacity. Increased photosynthesis, particularly during the period of seed filling, will increase final seed weight and yield.

Analysis of factors regulating photosynthetic quantum efficiency - Urbana, IL. A series of techniques have been developed to isolate and purify a light-harvesting pigment-protein that is the predominant chloroplast membrane polypeptide. This complex has been incorporated into model phospholipid membranes. Ongoing structural and functional studies of this system will allow elucidation of molecular events that play major roles in regulating photosynthetic quantum efficiency.

In studies of chloroplasts isolated from naturally-occurring atrazine-susceptible and atrazine-resistant weed biotypes, the nature of an herbicide binding site in the chloroplast membranes has been characterized. This has allowed development of a model explaining specificity of herbicide binding. These data will be of value in combating problems of induced herbicide resistance and in the chemical design of new photosynthetic herbicides.

Control of carbon assimilate partitioning in green plants - Beltsville, MD. Photosynthesis increases when moderate irradiance-acclimated soybean leaves are abruptly transferred to high irradiance; and the additional photosynthate accumulates as chloroplast starch. However, when plants are acclimated to high irradiance during leaf expansion, the additional

carbon flow is directed into sucrose synthesis and translocation. Increased sucrose-P synthetase (SPS) activity in leaves of high irradiance-acclimated plants corroborates earlier results which suggest that SPS may regulate photosynthate partitioning between starch synthesis and sucrose translocation.

Photosynthate partitioning into starch is also increased by shortening the daily photosynthetic period relative to length of the night. The increased starch synthesis in fully expanded soybean leaves occurs primarily at the expense of structural development and leaf thickening. The starch is then translocated as sucrose at night, preferentially to the shoot apices, thus favoring shoot growth, thinner leaves, and more efficient light trapping under the shorter photosynthetic period.

The enzymes invertase and sucrose synthetase of sugarbeet fibrous roots differ from the enzymes of the storage root with respect to specific activities, pH optima, cellular and tissue location, and, in the case of sucrose synthetase, nucleotide diphosphate substrate specificity. Results are being used to relate the role of these enzymes to the different form and function of the two root types.

Ecological constraints on utilization of light by crop plants, Beltsville, MD. Annual seed crops, ruderal weeds, and weeds from abandoned fields were compared in field plots and in a controlled environment chamber. Crops grew fastest in the controlled environment chamber because of higher leaf area ratio than ruderal species, and higher leaf area ratio, net assimilate rate, and single leaf photosynthetic rate than abandoned field species.

Progeny of Taraxacum officinale plants collected from cultivated fields, abandoned fields, and mown meadows were compared in a controlled environment chamber. Most rapid growth was in abandoned field plants because of their high photosynthesis rate; the slowest growth was in cultivated field plants because of their low leaf weight ratio and high specific leaf weight. Photosynthetic tolerance of low leaf water potential was greatest in cultivated field plants, and least in abandoned field plants. Tolerance of complete defoliation was greatest in the cultivated field plants.

Progeny of three individual Kent soybean plants selected for rapid growth in dry soil, low air temperature, and high light were compared. Under low stress conditions the progeny of the plant having best growth at high light had highest single leaf photosynthetic rates, and progeny of plants having best growth in dry soil and at low temperature had lower photosynthetic rates. Growth rates in low stress conditions were positively correlated with photosynthetic rates.

Photosynthesis by cotton cotyledons: A major force towards continued seedling growth - Mississippi State, MS. Epicotyl growth is relatively slow for cotton, making seedling establishment during the first week after emergence highly dependent on climate. Removal of the terminal bud of cotton seedlings increases the life-span of cotyledons and establishes a different pattern of aging and death. Cotton leaves contain several enzymes which can destroy proteins by removing amino acids from terminals. No enzyme capable of breaking a protein into two large units was detectable. Cotton leaves grown in CO<sub>2</sub> levels twice that of normal air fill with starch. Starch masks the chloroplasts from light and the photosynthetic rate declines. Drought is more severe during fruiting than during earlier stages. Such drought combined with high nitrogen application causes the most severe reduction in yield.

Carbon dioxide fixation by C<sub>3</sub> and C<sub>4</sub> plants - Raleigh, NC. The light inactivation of glucose-6-phosphate dehydrogenase in intact chloroplasts was inhibited by inorganic phosphate. Light modulation was apparently controlled by the inorganic/organic phosphate ratio. Results obtained suggest that flux of carbon through the oxidative pentose phosphate pathway could occur in the light and contribute to metabolite pools when the level of inorganic phosphate in the chloroplast was excessive. The major limitation was availability of NADP for the dehydrogenases. Exogenous magnesium inhibited chloroplast photosynthesis by stimulating phosphate exchange across the chloroplast envelope. Metabolites which compete with inorganic phosphate for transport reduced inhibition by magnesium. Inhibition was also prevented by exogenous potassium. It was determined that magnesium activated a potassium/proton exchange across the chloroplast envelope. In the absence of external potassium, magnesium caused an efflux of potassium and an influx of protons. The acidification of the stroma was responsible for effects on phosphate exchange. Results suggest that cytoplasmic factors may control both ionic composition and carbon metabolism of the chloroplast stroma.

Nucleic acid composition and photosynthetic activity as related to chloroplast senescence - Raleigh, NC. Thermal denaturation profiles of peanut DNA showed an average T<sub>m</sub> of 66.1°C and G+C content of 33.8%. Peanut DNA exhibited three distinct fractions when percent hyperchromicity was plotted against temperature on normal probability graph paper. These reflect intermolecular heterogeneity in base composition of peanut DNA. The genome size as determined by reassociation kinetics of the single copy DNA was close to the genome size determined by cytophotometry (1:1.2), a ratio derived from  $1.8 \times 10^9$  and  $2.1 \times 10^9$  base pairs, respectively. Peanut DNA reassociation and separation with hydroxyapatite chromatography yielded a DNA genome composition of 31% nonrepetitive or single copy, and 69% repetitive. The repetitive DNA possessed fast, intermediate, and slow DNA classes with DNA sequences repeated on the average of 95,000, 575, and 39 times each.

The reassociation kinetics of short and long DNA fragments revealed that fast and intermediate DNA sequences were interspersed among slow or single copy, and the single copy sequences averaged 2900 NT in length or more. Corn DNA from old and young plants displayed differential reassociation kinetics in the highly repeated nucleotide fraction up to Cot 10. Young DNA reassociated at a rate 20% faster than old DNA, indicating a shift or loss of repeated DNA along or from the genome through senescence.

The effects of oxygen tension and temperature on the dark release of  $^{14}\text{CO}_2$  following light fixation of  $^{14}\text{CO}_2$  - Raleigh, NC. For Panicum maximum, the total uptake of  $^{14}\text{CO}_2$  increased with temperature up to 38C for 20%  $\text{O}_2$  and up to 30C for all other  $\text{O}_2$  tensions; the total dark release during the first 4 minutes of darkness increased with temperature only for 20%  $\text{O}_2$ . The percent release showed no consistent pattern except that it was higher at 10C for all  $\text{O}_2$  tensions, and the percent release peaked near the end of the first minute of darkness at all temperatures and  $\text{O}_2$  tensions. For Panicum bisulcatum, the total uptake of  $^{14}\text{CO}_2$  increased with temperature up to 30C for all  $\text{O}_2$  tensions; the total dark release increased with temperature in the same way as total uptake; the percent release increased with increased  $\text{O}_2$  tension at all temperatures; and generally, the percent release decreased with increases in time during the first minute and to a nearly constant rate during the next 2 minutes.

## Technological Objective 2.

Improve nitrogen fixation efficiency of bacteria-plant associations and develop nitrogen-fixing capabilities in crops lacking this capability in order to reduce energy requirements for crop production.

### Research Locations:

5102	Albany, California
7602	Gainesville, Florida
3102	Peoria, Illinois
1109	Beltsville, Maryland
7802	Raleigh, North Carolina

### Selected Examples of Recent Progress:

Chemical triggers of nitrogen fixation - Albany, CA. Aeroponic apparatus constructed for study of legume growth was subject to contamination with extraneous microorganisms so that collection of pure root exudates was impossible. A closed recirculating system was designed to bathe plant

roots with growth medium. This system is more easily maintained in sterile condition. Two strains of Rhizobium japonicum were grown on agar plates to demonstrate chemotaxis. Root extracts and several pure plant growth regulators (cytokinins, gibberellins, ABA, triacontanol) were applied on paper discs to the plates. No effect was observed on either bacterial growth or mobility. Further experiments will determine if these compounds or mixtures affect nitrogenase activity of Rhizobium. Standardization of nitrogenase assay by acetylene reduction was accomplished. An instrument has been constructed to study possible chemotaxis of Rhizobium toward naturally occurring, or other, attractants. This apparatus measures light scattered by the bacteria to determine their position in a chemical gradient.

Nitrogen fixation by tropical forage grasses - Gainesville, FL. Plants in liquid nutrient solutions continued to excrete both amino acids and carbohydrates into the solution even as they approached maturity. Azospirillum or other diazotrophic bacteria multiplied when inoculated into the solution, whether or not additional carbon sources were added. However, inoculation did not improve the condition of the plants and often was harmful. Plants nearing maturity were less tolerant to reduction of the mineral nitrogen supply when inoculated with Azospirillum than when not inoculated. Even in such conditions, dinitrogen fixation by the inoculant organism was not detected. Several lines of evidence show that competition between the plant and Azospirillum can occur under stress conditions, and that in some cases the bacteria can induce collapse of the plant. This seems to provide some further evidence that beneficial effects of inoculation with Azospirillum occur early in the life of the plant, and that the stimulus from the inoculant organism is not provided by its capability to fix nitrogen.

Unique physiology of an algal nitrogen-fixing partner of a plant - Peoria, IL. Blue-green algae isolated from Azolla have been found to grow in the dark with an unusual sugar as an energy source. Since only few strains of free-living blue-green algae can grow in this way, the finding suggests that those algae isolated from a nitrogen-fixing partnership with the fern may be less photosynthetic in character than free-living strains. The isolated algae differ from similar free-living strains in that their nitrogen fixation when grown in the dark is two to threefold higher than in photosynthetically grown cells. The results suggest that, in the fern leaves, the unusual sugar supplied by the host plant provides necessary energy for the algae's growth and nitrogen fixation.

Azospirillum sublines carrying resistance markers for rifampicin and streptomycin derived - Beltsville, MD. These markers were demonstrated to provide unambiguous identification of these strains in soil. In soil pot experiments inoculation of corn seed with numbers of azospirilla

ranging from 10 to 1 million per seed resulted in the same number of bacteria (about one million) per gram dry root 14 days later. In a field experiment the number of marked Azospirillum increased to 1 million per gram dry weight of root at 14 days after planting, then declined to 1 thousand per gram after one month and remained at that level for the rest of the season. Native non-marked Azospirillum-like bacteria greatly outnumbered the marked inoculated strain during the period from one month after planting to the end of the season.

Preliminary evidence was obtained that root-microbial associations of certain marsh grasses fix nitrogen from the atmosphere.

Estimates of the quantity of nitrogen derived from associative nitrogen fixation were made on corn grown in plots which received either 2 or 6 kg of enriched dry matter  $m^{-2}$  before planting. This technique labels the organic nitrogen fraction of the soil and provides different amounts of mineralized nitrogen to the plants during the growing season. Azospirillum were used as inoculum at planting. Dry matter production from inoculated and uninoculated plots were similar. Plant material will be analyzed to determine quantity of nitrogen fixed.

Source of carbon-nitrogen nutrition during soybean development as relates to yield - Raleigh, NC. The observation that 80% of the nitrogen transported from roots to shoots of nitrogen-fixing soybean plants in the xylem is in the form of allantoic acid and allantoin suggests that assimilation of nitrogen fixed from  $N_2$  is biochemically more complex than originally thought. This indicates new areas of nitrogen metabolism that require additional biochemical and physiological investigation. The transport of allantoic acid and allantoin which have a 1:1 C:N ratio may represent a physiological mechanism of spacing carbon for support of other crucial processes in roots and nodules. Investigative results indicate 1) definitive effects of source of nitrogen assimilated on nitrogen composition of xylem sap, 2) constancy of predominate nitrogen transport forms throughout development under constant conditions of nitrogen nutrition, 3) predomination of allantoic acid and allantoin in sap of six Rhizobium-host plant genotype combinations, and 4) highly significant positive correlations of parameters associated with nodule development and function, with percent of total sap nitrogen as ureide. These points suggest that ureide content of sap (collected at different stages of development) in conjunction with total plant nitrogen accumulation data might be used to make reasonably accurate estimates of nitrogen fixation by soybeans growing in presence of soil nitrogen.

Genetics of nitrogen fixation and symbiosis in Rhizobium - Raleigh, NC.

Approximately 2700 colonies from mutagenized cultures of Rhizobium strain 32H1 have been screened for ability to form an  $N_2$ -fixing symbiosis with the tropical leguminous plant, Macroptilium lathyroides. After 3 cycles of retesting, the isolation of 3  $Nif^-$  strains is confirmed as being unable to reduce acetylene in both the free-living and plant tests, one ineffective

strain (Nif<sup>+</sup> in the free-living test but Nif<sup>-</sup> in the plant test), and one strain which shows enhanced nodulation and correspondingly increased levels of nitrogenase activity as measured by the acetylene reduction technique.

Under greenhouse conditions it was observed that inoculation of Glycine max var. Ransom with mixed cultures of Rhizobium japonicum strain 61A76 and Azotobacter vinelandii strain OP gave increased numbers of nodules as compared to inoculation with R. japonicum alone. Plants were inoculated with mixed cultures of R. japonicum and mutant strains of A. vinelandii unable to fix nitrogen (Nif<sup>-</sup>). After growth under nitrogen free conditions nodulation enhancement was observed in the presence of both Nif<sup>-</sup> and Nif<sup>+</sup> A. vinelandii strains. Thus, nitrogen fixation can not be the primary cause of nodule enhancement. Enhanced nodulation was also observed with the Trifolium repens - R. trifolii and the Vigna unguiculata - Rhizobium sps. symbiotic associations, indicating that this phenomenon is not limited to the G. max - R. japonicum symbiosis.

### Technological Objective 3.

Develop new and improved cell and tissue culture technology for plant improvement through increased genetic diversity and rapid vegetative propagation.

### Research Locations:

3102	Peoria, Illinois
1109	Beltsville, Maryland
3507	Madison, Wisconsin

### Selected Examples of Recent Progress:

Plant cell and tissue culture for the bioproduction of valuable chemicals - Peoria, IL. Conditions chosen for Cephalotaxus harringtonia callus initiation tended to become "optimal" with time: 25C and 100 mg/l inositol plus 25 mg/l hypoxanthine were best for callus growth. Initial pH was unimportant since final pH was always 4.2, regardless. In a factorial experiment a significant 5-way interaction indicated that the optimum level for one component depended on the levels of the other four variables: 1.65 g/l NH<sub>4</sub>NO<sub>3</sub>, no protein hydrolysate, full-strength Murashige and Skoog minor salts, 4% sucrose and 4 mg/l Kinetin gave 92% growth improvement. Certain callus lines which no longer produce cephalotaxine and its antitumor esters produce relatively large amounts of unknown alkaloids instead. The pattern of alkaloid production depends primarily on the presence or absence of NH<sub>4</sub>NO<sub>3</sub> in the medium. Several of these compounds have been detected also in normal callus or tree tissues and appear to be cephalotaxine precursors; hence tissue culture appears to

be an ideal tool for the study of alkaloid biosynthesis and its regulation. These studies are being pursued. The feasibility of using immunochemical techniques to characterize individual protoplasts was explored by injecting carrot protoplasts into rabbits to induce anti-carrot antibodies. Anti-carrot rabbit serum agglutinated not only carrot protoplasts, but also those from parsnip and Cephalotaxus. Such apparent cross-reactivity is contrary to the findings of Hartmann et al. (1973) and Strobel and Hess (1974), but supports those of Larkin (1977).

Application of tissue culture to crop improvement - Beltsville, MD.  
Methods have been developed and refined for the isolation and modification of the tumor-inducing plasmid of Agrobacterium tumefaciens, and of restricted plant DNA (nuclear and organelle) with identified markers. The goal is to develop systems for the transfer and expression of specific genes from one plant type to another. Several Agrobacterium-modified cell lines have been recovered. This plasmid system may provide the vehicle for the transfer and insertion of known genes and regulators from one cell type to another.

Anther and tissue culture techniques including techniques in woody plant propagation were developed with peach, rice, and wheat. Rice cells were cultured at inhibitory levels of the analog of lysine, aminoethylcysteine. Resistant cells grew rapidly in the presence of the inhibitors and were differentiated into whole plants. Seeds were collected. Selfed progeny (seeds) had 10% greater lysine than similar nonselected controls. This is the first evidence that in vitro selection pressure might select for higher lysine progeny. If these observations are further substantiated, a new powerful tool will be available to plant breeders.

Transfer of genetic information from bacteria to plants - Madison, WI.  
The interaction between the bacterium Agrobacterium tumefaciens and dicotyledonous plants results in a natural form of genetic engineering. The first step in the interaction is the transfer from the bacterium to the plant cell of a small portion of bacterial DNA. We have detected RNA copies of the plasmid DNA in tumor cells. Our results suggest that the RNA is a message for structural gene products. Some of these products may be replaceable, thus allowing us to introduce in their place desirable genetic traits; e.g., the enhancement of seed protein quantity and quality, increased photosynthetic efficiency and nitrogen fixation by non-legumes.

Differentiation of tissue cultures from crop plants - Madison, WI.  
Conditions for obtaining viable protoplasts from Nicotiana glauca were developed. Protoplasts were subsequently grown to callus and plants were differentiated from the calli. Additional experiments were conducted with soybean and potato callus tissues; the former have yet to yield shoots but the latter can be differentiated at will.

#### Technological Objective 4.

Develop technology for improving the absorption, translocation, and utilization of nutrients and water to increase crop production efficiency.

Activities under this technological objective are being implemented. This research is presently being conducted in part under NRP's 20010, 20100, 20730, 20760, 20770, 20780, and 20790.

#### Technological Objective 5.

Improve technology for better crop production under environmental stress.

#### Research Locations:

5100	Albany, California
7602	Gainesville, Florida
1109	Beltsville, Maryland

#### Selected Examples of Recent Progress:

Better understand the influence of plant cell structure - Albany, CA. Basic research has been initiated to elucidate the molecular basis for membrane fluidity and permeability in order to determine the plant cell plasma membrane permeability on the resistance of plants to temperature, salinity, and viral stress. Similar work carried out at Beltsville, MD, will be heavily drawn upon as well as similar work concerning animal membranes; however, no molecular structure work on plant membranes has been reported so far. The influence of cell wall structure on the glycoprotein sheaf, amount of cholesterol in the membrane and the differing mono-/divalent cation ratios are expected to show strong differences from animal membranes. The correlation with permeability measurements and chemistry of Drs. St. John and Hendricks should be immediate. These studies potentially lead to systems for altering resistance to stress by chemicals, specific thermal regimes, or others. Since lipids contain a framework of hydrocarbon chains, studies are conducted with the vibrational spectroscopy of such chains to characterize structure and mobility. Also, studies are conducted on the fluidity of membrane-like structures, directly, by introducing small spin labels into model structures and calculating the mobility of the labels from ESR line shapes.

Crop plants are sensitive to high levels of UV-B radiation - Gainesville, FL. Peas and soybeans were exposed in a greenhouse to high levels of UV-B radiation that were equivalent to 31%, 64%, and 125% increases in biologically effective radiation (approximately equal to 18%, 31%, and 46% reductions in stratospheric ozone, respectively). The highest treatment almost consistently showed detrimental effects on growth and photosynthetic component reactions, with the intermediate treatment often showing significant but less pronounced effects. The lowest UV-B treatment sometimes showed adverse effect on some processes. Peas were more sensitive than soybean. Reduced solar radiation under lamp fixtures in the greenhouse may have amplified UV-B effects. Small decreases that could occur in atmospheric ozone are not likely to have any effects.

Sugarcane leaf "freckling" induced only at very high UV-B - Gainesville, FL. UV-B radiation supplied by cellulose acetate filtered FS-40 lamps did not induce leaf "freckling" in sugarcane plants grown in a greenhouse under Si-deficient nutrient conditions as was hypothesized (based on published information from Mauritius). However, when cellulose acetate filters were removed in December 1978, "freckling" developed rapidly on all plants, with or without Si-nutrition. "Freckling" developed on outdoors-grown sugarcane only under Si-deficient treatments.

Stress effects on germinating seeds and seedlings - Beltsville, MD Studies of lipid fractions of wheat root membrane of BASF 13-338 pyridazinone treated wheat show a uniform reduction of linolenate in all polar lipid classes. Field experiments of winter grain response to BASF 13-338 were completed and indicated a direct relation of linolenic acid and cold hardiness. Chilling protection of early transplanted tomato with anti-transpirants was moderately successful.

Growth and metabolic changes during acclimation of plants to frost and drought - Beltsville, MD. Frost tolerance is marked by increases in phospholipid. Light treatment appeared to increase regeneration of phospholipids in frost injured rape leaves. Hardening of leaves caused no reduction in six phosphate dehydrogenase activity of leaves after freezing unhardened leaves suffered 25% reduction in activity. Dehydration of tissue causes a cold hardening stabilization of cell membranes.

Environmental control for plant growth - Beltsville, MD. Significant differences in sensitivity to water stress were observed among 11 cvs of Coleus following application of solutions of polyethylene glycol (PEG)-600 (-2.5, -5, -10, -15, or -20 bars) to the soil. Similar differences in cv sensitivity were observed among 6 U.S. cvs and 2 Niger cvs of cowpea. Plant response to osmotic stress varied with the number of applications and the age of the plants. The diffusive resistance porometer was more sensitive than the pressure bomb in detecting small differences in plant water status. Leaf water potentials recovered

considerably faster than stomatal conductances following rewatering. The molecular weight of the PEG solution used had a significant effect on plant response; solutions of PEG-1000 were considerably more toxic than PEG-600 solutions at -10 bars. Al-tolerant Dayton barley plants were more resistant to water deficits than were Al-sensitive Kearney plants. Pepper plants subjected to brief periods of water or osmotic stress were more tolerant of severe stress than were unhardened plants. The role of UV in Fe reduction was discovered. Conclusive evidence for the presence of UV radiation in various experimental and commercially available lamps including incandescent lamps, 4 metal halide lamps, and various fluorescent lamps was obtained. Regression equations for obtaining UV irradiances under FS-40 lamps filtered with cellulose acetate were developed.

Broad-band UV-B studies - Beltsville, MD. Broad-band UV-B studies were conducted in the greenhouse and the growth chamber on over 20 species and cultivars of vegetable and agronomic crops under a gradient of 50 to 500% increase in biologically effective UV (BUV) irradiation. Plants studied included cotton, peanut, wheat, rice, alfalfa, cucumber, pea, beet, tomato, rutabaga, okra, bean, radish, and turnip. Visual injury was observed in over half the species and cultivars studied. In most cases only slight or moderate UV damage was noted even when the plants were exposed to an increased level of BUV as high as 300-400%. The most dramatic evidence of UV injury was chlorosis in pea and cucumber, necrosis in pea leaves and pods, and reduction in leaf size in pea and cucumber. Increasing the BUV level by 100-400% reduced the total number of kernels in Pacific Triple Dwarf wheat by 20% but had no appreciable effect on average yield. Increasing the BUV level by 100% under field conditions had no consistent effect on growth or yield of bush bean, yellow squash, soybean, sugar beet, sweet corn, sorghum, broccoli, wheat, barley and rye. Disease severity of Colletotrichum lagenarium on cucumber and the percentage of leaf area of tissue infected decreased with increasing UV-B irradiance. However, disease severity of Cladosporium cucumerinum was not influenced by increases in the BUV level. Regression equations were developed for estimating weighted and unweighted UV spectral irradiances under FS-40 fluorescent sunlamps filtered with 0.127 mm cellulose acetate.

#### Technological Objective 6.

Develop new technology for control and regulation of biochemical, physical, and morphological processes of plants.

#### Research Locations:

1109	Beltsville, Maryland
1307	Ithaca, New York

Selected Examples of Recent Progress:

Detect and obtain from crop plants hormones that can be used to advantage in the production of crops such as corn, soybeans, cotton, and small grains - Beltsville, MD. Through the cooperative efforts of scientists at NRRC, ERRC and BARC enough crystals were obtained from the extraction of 180 kg rape pollen to identify the extremely biologically active plant steroid, brassinolide. Spectroscopic and crystallographic data show that the active steroidal molecule has an empirical formula of  $C_{28}H_{48}O_6$  and a molecular weight of 480. The level of this molecule in rape pollen is about 100 parts per billion. Brassinolide applications to bean internodes in microgram quantities under bioassay conditions result in rapid localized growth that causes the internodes to split. In the presence of auxin, a natural plant hormone, brassinolide enhances the auxin response of bean segments as much as four fold. A project to synthesize brassinolide or an active analogue is underway as are physiological studies to determine how this new and unique growth promoter can be utilized in agriculture and to determine its role in the physiology of plant growth and development.

Mechanism of light regulation of plant growth and development - Beltsville, MD. A new electrical probe has been constructed to measure electric charges in plant tissue. Use of this instrument will enable the detection of rapid changes in the electrical field around plant tissues after subjecting them to light and gravity treatments. The change in charge probably reflects a change in charge of the cell membranes and regulates plant growth. Investigations show the charge is greatest in a zone, 1 to 2 cm below the tip of soybean stems. This zone is also the region that responds to geotropism.

Control of the biosynthesis of proteins and amino acids in legume seeds - Ithaca, NY. Methionine analysis of ethionine-resistant "lines" of soybean cells has been continued. Of the 125 lines that have been analyzed, 8 have shown repeatedly (at least 4 generations) as containing an elevated level of non-protein methionine (4 to 20 times as high as normal lines). Analysis of methionine-fed soybean plants demonstrated that methionine is absorbed by the roots, transported to the leaves and beans and accumulates in these tissues. The addition of methionine to soybean cotyledon cultures resulted in a 20% increase in methionine content of the protein, that was correlated with an increase in the 11S storage protein, a decrease in the 7S storage protein and a decrease in the  $\beta$  subunit of the storage protein. The messenger RNA fraction from soybeans was shown to contain messenger RNA for some storage protein subunits.

Mechanism for control of soybean protein synthesis - Ithaca, NY. To isolate specific messenger RNA for storage proteins on soybean seeds for ultimate use in isolating genes for storage proteins, methods were perfected to permit the large scale purification of active messenger RNA's (mRNA's) from immature soybean cotyledons. Polysaccharide-like materials which have, in the past, inhibited the in vitro translation of these mRNA's, were removed by hydroxylapatite chromatography subsequent to the oligo dt-cellulose affinity chromatography of poly(A)+mRNA's. After sizing the mRNA's on the basis of their sedimentation properties in sucrose gradients under denaturing conditions, RNA's were electrophoresed in SDS-containing polyacrylamide gels. RNA's of particular molecular weights were electrophoretically eluted and translated in vitro. Earlier it was shown that mRNA's from immature seeds produced subunits of the soybean storage proteins when translated in a wheat germ-extracted in vitro protein synthesizing system.

DNA complementary to mRNA has been enzymatically produced using reverse transcriptase from avian myeloblastosis virus in preparation for molecular cloning of specific mRNA sequences.

#### Technological Objective 7.

Develop technology for reducing damage to crop plants from air pollutants.

#### Research Location:

3102	Peoria, Illinois
1109	Beltsville, Maryland

#### Selected Examples of Recent Progress:

Studies to expand the comparison of pigments in four genetic lines of soybeans under laboratory and normal field growing conditions and under enhanced UV-B irradiation - Peoria, IL. The study of plant pigments and their functions in growth and photosynthesis proceeded in two directions: 1) Improvement of analytical techniques, and 2) theoretical relationship of pigment ratios. High-performance liquid chromatographic (HPLC) methods for chloroplast pigments were developed and sample preparation for carotenoids and chlorophylls were considerably improved. A rapid procedure of pigment sample preparation has been devised using commercially available cartridges of reverse-phase packings and millipore filters which reduces time required from 3 hours to 20 minutes. In addition new HPLC analytical techniques for flavonoids were explored as well as methods for isolation of whole cells from soybeans. Analytical techniques allowed the investigations to relate chlorophyll deficient mutant soybean and peanut plants to etiolated and partially greened plants. Relationships were found between accessory pigments and chlorophyll a in mutants which suggests the progression of greening in the normal plant.

Yields of sweet corn were reduced an average of 9% per year by photochemical oxidants - Beltsville, MD. In the past two years, open-top chambers with carbon-filtered and unfiltered air have been used at Beltsville to assess the impact of photochemical oxidants on yields of sweet corn. The average yields of four commonly-grown cultivars in unfiltered air were reduced 9.9% in 1977 and 8.5% in 1978. Corn in plots without chambers yielded about the same as in the unfiltered chambers. The higher yields in filtered air were due to better kernel development at the tips of ears in the filtered air rather than to any increases in ear size. Similar yield reduction can be expected for sweet corn in other Atlantic Coast States since the levels of oxidants are about the same throughout the region. Silver Queen was the most productive cultivar and the most tolerant to oxidants based on comparisons of oxidant leaf injury.

Effects of ozone on growth of cotton and lima beans - Beltsville, MD. An antizone experimental chemical, N-[2-oxo-1-imidazolidinyl)ethyl]-N phenylurea (EDU), was applied as leaf sprays and as soil drenches to assess the effects of ozone on growth of cotton and lima beans. The EDU sprays on cotton in the greenhouse increased plant dry weight, average boll weight and seed weight per boll but it decreased lint yields and the percentage lint versus seed. EDU increased micronaire values (lint fineness) but it tended to decrease fiber strength. Percentage oil content of seeds of Gregg 45, ozone sensitive, was increased but it had no effect on Coker 310 and Stoneville 213. EDU did not alter protein content of these cultivars. EDU prevented some ozone injury to leaves of field-grown lima beans just prior to early harvest, but it did not increase bean yields. EDU applied as a drench reduced yields by 10% for the late harvest of lima beans.

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## National Research Program 20180

### CROP POLLINATION AND HONEY PRODUCTION

This National Research Program involves research on projects designed to improve beekeeping management for honey production and crop pollination. Studies include colony management, control of diseases and pests of bees, honey bee breeding and genetics, bee poisoning by pesticides, wild bee biology, properties of apiary products and the use of bees in pollinating crops.

NPS Contact: E. C. Martin

#### Technological Objective 1.

Improve management of honey bees for most effective crop pollination and honey production.

#### Research Locations:

5502	Tucson, Arizona
1110	Beltsville, Maryland
3507	Madison, Wisconsin

#### Selected Examples of Recent Progress:

Bee nutrition and pollen substitutes - Tucson, AZ, Beltsville, MD and Madison, WI. Bee nutrition studies focus on the adequacy of natural pollens, and the development of suitable substitutes for natural pollen to maintain the health and productivity of honey bee colonies. The brood rearing potentials of nine pollens were evaluated using a 10-day standardized bioassay. Results ranged from 90 sealed cells on saguaro pollen to 0 sealed cells on dandelion pollen. As dandelion is a major source of spring pollen in much of the country, it will be important to identify its dietary deficiencies and means of supplementing them. Biochemical studies of proteins, amino acids and enzymes present in pollens, isolation of factors which make pollen attractive to bees, maintenance of body protein levels in adult bees, relationship of nutrition to susceptibility to European foulbrood continue. Microbiological examinations of pollens before and after storage in hives indicated the frequent presence of several species of Bacillus, particularly B. subtilis. These and other microorganisms may influence the nutritive value and preservation of stored pollen (bee bread). Studies of honey bees' steroid requirements indicated that the addition of cholesterol to a standard synthetic diet increased the rate of brood rearing. Three other phytosterols were ineffective. Brood rearing in colonies fed a whey-yeast pollen substitute was increased 2.5 times by the addition of a crude pollen extract encapsulated in a starch polymer.

Indoor wintering of honey bees - Madison, WI. The survival rate of 64 colonies of honey bees overwintered in an indoor controlled environment storage facility was 90.6%. The confinement period was from 15½ to 17 weeks with no apparent differences in survival due to length of confinement. The average consumption of stores during the confinement period was 14.5 lbs. The survival rate of 40, 4-frame nucleus hives overwintered in the same facility for the same period was 47.5%. An attempt to overwinter banks of 30 queens in each of two colonies in the facility was unsuccessful. No advantage over outdoor wintering has been demonstrated to date.

#### Technological Objective 2:

Improve methods of protecting bees from pesticides, diseases, pests and pollution.

#### Research Locations:

5502	Tucson, Arizona
7413	Baton Rouge, Louisiana
1110	Beltsville, Maryland
5610	Laramie, Wyoming

#### Selected Examples of Recent Progress:

Protecting bees from pesticides - Tucson, AZ, Laramie, WY. Studies involving 16 treatments and 160 colonies of honey bees adjacent to cotton fields were carried on at Casa Blanca, Arizona. The value of supplying water inside hives covered with burlap was clearly demonstrated.

Systemic insecticide contaminates nectar - Tucson, AZ. Onion plants sprayed with dimethoate had nectar contamination that gradually decreased from 3 ppm to 0.2 ppm over a 2-week period. Sugar syrup containing these levels was harmful to colonies of honey bees.

Micro-encapsulated methyl parathion damage - Laramie, WY. In a case history study in Wyoming of 265 colonies (8 apiaries) within flight range of an alfalfa field treated with Penncap-M, 53 colonies were killed, 111 severely damaged, 80 moderately damaged and 21 unharmed. Total damage to local beekeepers is estimated to be more than \$7,000. With the use of less toxic pesticide and proper precautions, the loss could have been completely avoided. Combs containing pollen contaminated with Penncap-M when placed in nucleus hives 14 months after contamination increased bee mortality up to 72 times mortality in control colonies.

Bacillus thuringiensis for control of greater wax moth - Beltsville, MD. Of 30 isolates of B. thuringiensis tested, two have been formulated by commercial companies for field testing. Results to date are promising.

Spiroplasma from honey bee and tulip poplar and magnolia blossoms are distinctly different - Beltsville, MD. Approximately 10,000 bees were examined for spiroplasma in 1978. Spiroplasma from four States were compared by the spiroplasma deformation test. Bee spiroplasma reacted within one dilution but no cross reaction was observed between bee and plant spiroplasma. Plant blossoms are probably not the source of honey bee spiroplasma.

Diagnosis of honey bee disease samples - Beltsville, MD. A total of 1,969 samples were diagnosed during 1978. Of these, 823 were American Foulbrood, 363 European Foulbrood, 39 nosema disease, 3 septicemia, 2 paralysis, 2 other diseases and 106 samples negative. Eighty isolates of Bacillus larvae were examined for sensitivity to oxytetracycline. No evidence of drug resistance was observed.

Nosema locustae and Nosema acridophagus not infective to honey bees - Laramie, WY. These organisms, used in biological control of grasshoppers, were not infective to honey bee larvae or pupae nor to adults fed the microsporidians as larvae.

No satisfactory control for chalkbrood - Laramie, WY. The following materials were tested for control of chalkbrood (Ascosphaera apis) Benomyl, Amphoterecin B, cyclohexamide, econazole, sorbic acid, griseofulvin and citral. Only citral showed some promise and tests will continue with it.

Resistance to chalkbrood - Tucson, AZ. Selection, breeding and testing colonies for susceptibility and resistance to chalkbrood continues.

Control of greater wax moth by inoculative releases of insects carrying radiation-induced factors of decreased fitness and genetic load - Baton Rouge, LA. Control is based on the concept that induced mutations decrease the insect's fitness to function in its highly specialized ecological niche in the brood combs of bee hives. Data from three tests indicate that 14 months after inoculative releases of moths containing genetic defects, marked reduction of infestation was achieved to distances of 27 miles from the release site.

### Technological Objective 3:

Determine pollination requirements of economically important crops.

### Research Locations:

5502	Tucson, Arizona
7413	Baton Rouge, Louisiana
5702	Logan, Utah
3507	Madison, Wisconsin

Pollination in greenhouses - Tucson, AZ. It was demonstrated that bees will fly and pollinate crops in single and double walled polyethylene greenhouses. Six times more canteloupes were grown per unit space in greenhouses than are presently grown under field conditions in Arizona.

Reflection of ultra-violet light from cucumber flowers - Tucson, AZ. Ultra-violet light is reflected from cucumber flowers. Visual acuity of honey bees extends to the ultra-violet so color invisible to man may strongly influence visits of honey bees to flowers. This might be an important consideration for plant breeders developing hybrid crops which must be cross-pollinated by bees.

Determining the pollination requirements of Fairchild tangerines - Tucson, AZ. Previous work has indicated that yield of Fairchild tangerines is increased when flowers are cross-pollinated with pollen from other varieties. The following percentage fruit set was obtained when hand pollinations were carried out using pollen of Minneola tangelo (49%), Valencia orange (40%) Hamlin orange (30%) Lisbon lemon (14%) and Fairchild tangerine (0 %). Fairchild trees caged with bees and pollinator trees produced a good crop of fruit, while trees caged with neither bees nor a pollinator tree produced almost no fruit.

Rabbiteye blueberry pollination - Baton Rouge, LA, cooperating with Tuskegee Institute. Cage experiments demonstrated that "Menditoo" and "Tifblue" varieties require pollination by bees for economic production.

Physiology of alfalfa fertilization - Tucson, AZ. Five alfalfa clones have been established representing a wide range of attractiveness to bees, nectar secretion, flower volatiles and self and cross compatibility. Clarification of these aspects will continue for better understanding of the usefulness of these factors in plant breeding, pollination efficiency, seed production, and development of hybrids.

Morphological variants within and between isogenic lines of carrots - Madison, WI. Yields of hybrid carrot seed have been disappointingly low and inadequate pollination has usually been considered the cause. Scanning electron microscope studies of some genotypes indicate that morphological problems of ovaries and stigmas might preclude adequate fertilization even if pollination were satisfactory.

Measurement of atmospheric electrical potentials - Madison, WI. A major obstacle to the interpretation of insect response to environmental electrical stimuli has been the inability to monitor atmospheric electrical potentials. A field mill of unique design has been developed which is very accurate and reliable. An application for a public patent is being drawn up. The instrument will be useful to biologists who are attempting to evaluate animal response to environmental electrical stimuli.

Electrical potentials of honey bees - Madison, WI. Foraging honey bees returning to the hive carry rather large surface electrical potentials but nonforaging, flying bees have no such potential. Electrical potentials have a daily and seasonal rhythmicity but their source is unknown. Flight altitude contributes to the magnitude of the potential. These studies may have application in pollen collection, crop pollination and other aspects of bee management.

Honey from soybeans - Madison, WI. Studies in southeast Missouri indicate that some varieties of soybeans on certain types of soil provide good honey crops. Full determination of all factors involved with attracting bees to the crop is prerequisite to using bees for pollination purposes.

#### Technological Objective 4.

Identify and study biology of wild (non-Apis) bee pollinators and improve methods of using wild bees for crop pollination.

#### Research Locations

1111	Beltsville, Maryland
5702	Logan, Utah

A pollinator of commercial pome and nut crops developed - Logan, UT. Management techniques for Osmia lignaria have been effectively worked out. In orchard tests these bees successfully pollinated apples, producing a near normal crop under adverse weather conditions.

A candidate pollinator of red clover tested - Logan, UT. Red clover with its deep corolla has been considered a bumble bee flower, but bumble bee populations are usually too low to provide complete pollination and maximum seed yield. A Eurasian bee, Osmia coerulescens, was successfully tested as a pollinator of red clover. Field populations nested in a field shelter and collected red clover pollen. A caged population of the bee increased its population ten-fold. Currently, red clover seed yields are much below maximum potential. This bee could become a manageable pollinator.

Wild bee candidates for specific crop pollination - Logan, UT. Osmia cornuta was field tested for orchard pollination; Melitta leporina for alfalfa; seven species of solitary bees released in the greenhouse readily worked wild onions but would not visit hybrid onions; both high and low-self fertile sunflower lines produced more and heavier oil seeds when bees had access to the flowers than when bees were excluded.

Expanding identification and biological knowledge of native bees - Logan, UT. The 3,000 species of wild bees in the United States are a very important natural resource for pollinating both crops and wild plants. We have a good understanding of the biology of less than 10 percent of these bees. Studies of the life cycle, biology and seasonal emergence patterns of Megachile flavipes and M. nana were completed. A leafcutter bee parasite Coelioxys minutus was studied. Biological studies of the following bees were completed in the greenhouse: Osmia texana, O. marginipennis, O. coerulescens, O. fulviventris, Megachile concinna, Chalichodoma ericetorum, Hylaeus spp., and Heriades spp. P. L. 480 cooperators in Poland established populations of the following candidates for management and these will be field tested in domiciles in 1979: Megachile willoughbiella, M. alpicola, M. argentata, M. centuncularis, M. rotundata and Osmia coerulescens. These are potential alfalfa pollinators.

Pheromones and other chemical products of bees - Beltsville, MD. In cooperation with chemists at NIH, the mandibular glands of Colletes were found to produce citral and linalool, an aggregant pheromone, and the Dufour's glands produced lactones which polymerize to form a water-proof polyester, which is the broad cell lining. The finding of a high molecular weight polyester is unique. Its synthesis from lactones may be of interest to the plastics industry. The complex cephalic pheromones of the bees, Pithitis smaragdula, Melissodes denticulata, M. desponsa and Anthophora abrupta were analyzed.

#### Technological Objective 5.

Improve honey bee breeding and rearing, knowledge of bee genetics and germplasm maintenance.

#### Research Locations:

7413	Baton Rouge, Louisiana
3507	Madison, Wisconsin

#### Selected Examples of Recent Progress:

Genetics of defensive behavior (stinging) of honey bees - Baton Rouge, LA. Ten chemical components of honey bee alarm pheromones were tested in the laboratory. Two chemicals, N-decyl acetate and benzyl alcohol, failed to consistently stimulate workers to respond. Colony differences in response to several of the chemicals were observed. There was wide variation in response to isopentyl acetate and 2-heptanone. Attempts are being made to estimate heritability of time to react and duration of reaction.

Heritability studies of hoarding behavior, resistance to Nosema apis infection, response to alarm chemicals and longevity indicated a correlation between hoarding and response to alarm chemicals; and between longevity and Nosema resistance.

Depletion rate of sperms from the spermatheca of a laying honey bee queen - Baton Rouge, LA. Queens tested at the start of laying had 5.0 million spermatozoa in their spermathecae. After laying about 63,000 eggs, 3.25 million sperms remained in the spermatheca and after laying about 132,000 eggs, 2.49 million remained. The queens used one-half of their spermatozoa from June to mid-November.

Instrumental insemination of honey bees - Baton Rouge, LA, was improved if worker bees had free access to queens following insemination, and drones used for insemination were 2-week-old adults.

Improved liquid nitrogen storage of spermatozoa - Baton Rouge, LA. A semen diluent consisting of DMSO, egg yolk and  $\text{PO}_4$  buffer caused more spermatozoa to reach the spermatheca than previously used diluents, but percentage egg hatch was reduced.

Africanized bees in Venezuela - Baton Rouge, LA and the University of Kansas. A laboratory and several apiaries have been established in the vicinity of the Queen Rearing Center managed by the Ministry of Agriculture near Maturin, Venezuela. Africanized bees are now widely spread in Venezuela. The process of africanization is being studied by recording the proportions of africanized and European progeny produced by genetically marked queens that are allowed to mate naturally. Forty colonies are being observed to determine the frequency of "takeover" of European colonies by swarms of africanized bees. Gathering and hoarding abilities of africanized and European stocks are being compared in the same apiary. Methods to successfully introduce European virgin queens into colonies of africanized bees are being studied.

Comparisons of normal and "disappearing disease" honey bee stocks - Baton Rouge, LA, Beltsville, MD, Laramie, WY and Ohio State University. Basic biological and behavioral characteristics of colonies from four different stocks were compared (2, no complaint of disappearing disease; 2 with a stated history of disappearing disease). No differences were apparent in numbers of adult or immature bees; honey or pollen storage; longevity; cluster temperatures or temperatures of gathering bees returning to hives.

Gentle bees - Madison, WI. A gentle honey bee genotype has been developed and is being maintained through inbreeding for use as a hybrid parent. The line is being tested for its combining ability with productive stock.

#### Technological Objective 6.

Develop methods of detecting honey adulteration; increase industrial uses and identify biological characteristics and components.

Study food potential of bee-gathered pollen. (This T.O. is assigned to NRP 20520, but is briefly included here to present all apicultural research in one document).

#### Research Location:

1402 Philadelphia, Pennsylvania

Tests developed to distinguish corn products from honey - Philadelphia, PA. A thin layer chromatography procedure was developed and recently approved by the Association of Official Analytical Chemists as a standard method for analyzing honey and detecting adulterations. The speed and sensitivity of the test make it well suited for screening large numbers of samples. Suspect samples may be further verified by carbon isotope ratio tests developed earlier. A private laboratory is being equipped in Navasota, Texas, to detect any type of honey adulterant.

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National Research Program 20190

IMPROVED METHODS AND EQUIPMENT FOR PRODUCTION OF FIELD, HORTICULTURAL AND FIBER CROPS

This program involves development and improvement of equipment and techniques to solve urgent problems in the production of a wide variety of field and horticultural crops. The problems addressed are associated with harvesting, farm processing after harvest, planting and other cultural operations, and the improvement of environmental facilities, such as greenhouses and growth chambers. Reductions of losses, of fossil fuel use and of costs for labor and machinery are emphasized. The research is primarily of an engineering nature, but involves extensive cooperation with crop scientists, soil scientists, horticulturists and representatives of the equipment industry.

NPS Contact: Vacancy

Due to the vacancy an Annual Report was not prepared.

Special Research Program (under NRP 20160)

PRODUCTION AND CONTROL OF NARCOTIC PLANTS

This Special Research Program works to affect the production economics of illicit narcotic crops so as to give licit agricultural enterprises a competitive advantage and, secondly, assure that the United States has an adequate and stable supply of raw materials to meet its medical needs for codeine at reasonable cost.

NPS Contact: Quentin Jones

A separate Annual Report was not prepared this year.

## Special Research Program

### GENETIC VULNERABILITY

The mission of this SRP is to make visible and give emphasis to the common concern of 21 parent NRP's and 2 other SRP's to reduce the genetic vulnerability of crops to losses from pests and environmental stresses. The commodity programs, the basic science programs, the plant germplasm program, and the pest control programs all are intended to lead to the efficient production of high quality, nutritious, safe crops, well adapted to their environment and cultural practices, and so protected from pests and environmental stresses that losses would be held to a minimum. The program is especially designed to minimize the probability of catastrophic losses such as occurred during the southern corn leaf blight epidemic and to enhance our ability to recover quickly from any epidemics that may occur.

NPS Contact: C. F. Lewis

#### Technological Objective 1.

Improve the national system for collecting, maintaining, evaluating, documenting and distributing plant genetic resources chosen for systematic preservation.

#### Research locations<sup>1/</sup>:

5602	Fort Collins, Colorado
7616	Miami, Florida
7707	Experiment, Georgia
7705	Savannah, Georgia
3408	Ames, Iowa
1100	Beltsville, Maryland
1205	Glenn Dale, Maryland
1308	Geneva, New York
5802	Pullman, Washington
3507	Madison (Sturgeon Bay), Wisconsin

<sup>1/</sup> About 40 other sites where germplasm collections are kept.

#### Selected Examples of Recent Progress:

Cross-referenced to NRP 20160

Examples of recent progress for this technological objective are cross-referenced to NRP 20160, Plant Germplasm. Highlights of activities include (1) Design and partial implementation of national system of clonal repositories for fruit and nut crops, and (2) design and partial implementation of a computer-assisted information system for managing the inventory of stocks and data in the National Plant Germplasm System.

Of special significance was the reestablishment of the National Plant Genetic Resources Board (NPGRB) by Secretary's Memorandum No. 1875 Revised, February 23, 1978. The Board submitted to Secretary Bergland its report, "Plant Genetic Resources, Conservation and Use." A delegation of Board members and Departmental officials met with the Secretary in October 1978, and discussed with him the national importance of the conservation and use of plant genetic resources. The Secretary authorized the printing and public distribution of the report. Four thousand copies were distributed to scientists, administrators, commercial companies, farm press, and others. An additional 1,000 copies are on order. A portion of the report is repeated below.

## I. INTRODUCTION

### Lack of Native Crops in the United States

If American consumers were asked to live on food from crops native to the United States, they would probably be shocked that their diet was limited to sunflower seeds, cranberries, blueberries, strawberries, pecans, and not much else. Bread, cereals, potatoes, fruits, and vegetables would be missing from their tables. Tobacco would be available, but they would have no cotton or flax textiles for clothing and linens. If the United States had to import the food we eat and fiber used to clothe and house us, this would make our balance of payments for oil look small by comparison. Fortunately, we do not import food and fiber directly; however, resources that support our domestic food and fiber production are imported.

Without the systematic introduction and use of germplasm resources the average acre yield of corn could not have risen 320 percent from 1930 to 1975. Moreover, the energy required to produce the 1975 corn crop would have increased oil imports by millions of barrels if yield per acre had remained at the 1930 level.

### Long History of Plant Introduction

In precolonial and colonial days the early settlers found few of the crops they had known in the Old World. The Indians grew some corn, beans, and squash; however, these crops had been brought into the future United States much earlier by Indian tribes from what is now Mexico.

In the early settlement days immigrants to the United States quickly learned that they had better bring seed with them. The U.S. Government early recognized this paucity of seed and encouraged the search for seed of adaptable crops. In 1819, American consuls overseas were asked to collect seed of useful plants and send them to the United States. From 1836 to 1862 the U.S. Patent Commissioner administered the introduction of plants. In 1862 the U.S. Department of Agriculture was established. Since that time various agencies of the U.S.D.A. have accelerated plant exploration and plant introduction activities.

## The Current Challenge for Food and Fiber

The United States and the world face many agricultural challenges now and in the future. During the past 60 years the population of the world has grown from over a billion-plus to 4 billion. It has been predicted that the population may reach 6 or 8 billion by the end of this century.

Repeated studies have shown that if the human family expects to feed its burgeoning numbers, "We have to find in the next 25 years, food for as many people again as we have been able to develop in the whole history of man 'til now" (Jean Mayer 1975). In addition to this humanitarian aspect, bountiful and secure agricultural production is essential for the welfare and economic prosperity of nations.

Before the dawn of recorded history people began to become less dependent on hunting and foraging by turning to the cultivation of plants. Throughout the centuries plants judged to be superior were saved for propagating subsequent crops, some of which were doubtlessly chance or man-made hybrids. Thus, a vast number of "folk" varieties were developed in all parts of the world. Great genetic variability existed within and among these varieties. Moreover, that portion of species not chosen for cultivation generally survived in nature, because the pressure of the human population and advanced agricultural technology had not yet destroyed their natural habitats. In this century the situation that existed so long has changed and continues to change rapidly.

Professional plant breeding began 60 or 70 years ago with the rediscovery of Mendel's laws and the development of the chromosome theory of heredity. By applying these scientific principles breeders developed modern crop varieties generally highly uniform and specialized for yield, quality, and adaptation to specific environments. The constant release of improved varieties and the adoption of advanced production technologies resulted in remarkable increases in agricultural productivity. The superiority of these modern varieties over folk varieties led to their widescale adoption in this country and in other parts of the world. Many old varieties were abandoned with serious loss of these important plant genetic resources. Genetic resources in the wild as well as those in cultivation as folk varieties are rapidly disappearing.

Responsible agricultural leaders in this country and abroad have recognized for many years that plant genetic resources were being lost and that genetic variability among varieties was being reduced. The urgency of the southern corn leaf blight epidemic of 1970 shocked the nation into considering the conservation and proper use of plant genetic resources as activities of first importance to its continued well being.

Tragic epidemics have occurred since Biblical times. Recent examples are the Irish potato famine of the 1840's, the Ceylon coffee rust epidemic in 1870, the United States wheat rust epidemic in 1916 and the Bengal rice epidemics in 1942. The destruction of chestnuts several years ago and the current attack by the pathogen causing Dutch elm disease add to the list. Droughts in India, Africa, and our own Midwest and Far West in recent years emphasize that crops are vulnerable to stresses.

The term "genetic vulnerability" was coined to explain the southern corn leaf blight epidemic of 1970. In the genetic vulnerability of crops, uniformity is the key factor. The probability of an epidemic is increased when large numbers of plants are genetically alike. If one becomes susceptible, all become susceptible.

Although genetic diversity offers some protection against epidemics it does not guarantee that one will not occur. Producers and consumers want improved varieties with high yields, good quality and uniformity of product. They want varieties that lend themselves to low production costs. Genetic diversity is sacrificed because everyone wants to grow the best variety. The farmers want to grow the variety that makes them the most money. The seedsmen and breeders want to breed the best variety and capture as much of the market as they can. Breeders tend to use the better varieties as breeding stocks for further advances, which in turn reduces the genetic variance among varieties. Mechanized farming requires uniformity of seeds, maturity, and plant height.

Breeders now tend to release varieties with greater genetic diversity within them than they formerly did when the "pure line" theory was more in vogue. This trend helps; however, genetic diversity within varieties planted, by itself, will not adequately minimize the risks. Genetic vulnerability may be minimized most effectively by a sound research program in each of the seven phases of the program described in this report. Thus, genetic vulnerability is not simply uniformity in the fields; it is related to such factors as our ability to respond quickly to unexpected conditions. Our ability to respond should be related to knowledge of the crops and their relationships to pests and physiological stresses.

In 1970 the fungus (Bipolaris maydis) causing southern corn leaf blight spread across the nation. Losses reached 50 percent in some States and 15 percent nationally. This threat to the existence of a major crop created so much alarm that the Agricultural Board of the NRC appointed a committee on Genetic Vulnerability of Major Crops. This committee considered (1) what caused the corn blight epidemic of 1970, (2) how vulnerable crops were to attacks by pests, and (3) what should be done to hold losses to low levels and reduce the probability of epidemics. The book "Genetic Vulnerability of Major Crops" was issued by the NAS in 1972. The chapter on "The Challenge of Genetic Vulnerability", said in part, "Two points are clear: (a) vulnerability stems from genetic uniformity; and (b) some American crops are on this basis highly vulnerable. This disturbing uniformity is not due to chance alone. The forces that produced it are powerful and they are varied. They pose a severe dilemma for the sciences that society holds responsible for its agriculture. How can society have the uniformity it demands without the hazards of epidemics to the crops that an expanding population must have?"

A partial answer to this question was provided in a special report by an ad hoc subcommittee of ARPAC, issued in 1973 by the U.S. Department of Agriculture and the National Association of State Universities and Land Grant

Colleges. The subcommittee recommended that the Secretary of Agriculture appoint a National Plant Genetic Resources Board to assure the proper management of these national resources. A Board at this level was considered to be vital to the effective coordination of many efforts among public, private, and international groups.

In 1975 the Secretary of Agriculture established the NPGRB to advise him on national needs for the assembly, description, maintenance, and effective use of living resources in plant improvement programs. Secretary's Memorandum No. 1875 Revised, dated February 23, 1978, reestablished the Board.

#### Role of Plant Genetic Resources in Agriculture

Crop production can be improved in only two ways: (1) By improving the genotypes of the plants, and (2) by improving the environment through cultural practices and non-heritable protection from pests. All knowledge and practices must be channelled into these two mutually dependent avenues or they cannot influence production. Plant genetic resources are used in the first of the two ways to improve and sustain crop productivity.

Plant genetic resources extend from wild species to varieties in production. A program in agricultural research connects these extreme types of plant genetic resources. Because this work is scattered geographically, involves all crops and disciplines, and is shared by State and Federal agencies and industry, it is easy to miss the significance of the total program. The capability for the United States to carry out this work demands that the technical competence required in all areas of germplasm biology be assessed and that necessary steps be taken to insure its availability.

Genetic improvement of crops requires that plant genetic resources be collected, maintained, and used. the work may be divided into seven phases with the phases falling into a natural sequence, as follows:

- (1) Collecting, maintaining, evaluating, documenting, and distributing plant genetic resources. This phase helps to provide the nation with the plant genetic resources to meet current and future needs. It is of primary interest to the NPGC.
- (2) Understanding the genetic variability and geographic distribution of cultivated species and their taxonomic and cytological relationships with closely related species.
- (3) Screening plant genetic resources for specific, desirable characteristics. This should be done in each relevant ecological region for such characteristics as pest resistance, maturity date, nutritive quality, photosynthetic efficiency, drought tolerance, adaptation to problem soils, and fruiting efficiency. Genes for accomplishing improvement objectives must be located; genetic variation for the characteristics must exist before progress through breeding can be made.

- (4) Studying the genetic mechanisms controlling the inheritance of desirable characteristics. Such knowledge is required for determining breeding objectives, selecting parental materials, and choosing appropriate breeding methods.
- (5) Combining genes from diverse sources into improved strains more useful to plant breeders. Genes for desirable characteristics are often found in stocks inferior to cultivated ones; they are seldom found within the same stock. This phase is sometimes called developmental breeding. It is a connecting link between basic and applied research, and it sorts out those objectives that have a high probability of success for applied breeding from a large number of possibilities.
- (6) Breeding, releasing, and maintaining breeder seed of varieties and stocks of improved germplasm.
- (7) Producing high-quality planting seed and distributing it to farmers. This is the ultimate objective of all the preceding phases because it makes available seeds (or other plant propagules) with the inherent capability for efficient production of high quality crops, well adapted to our environment and cultural practices, and with as much "built in" protection as possible from pests and environmental stresses.

These phases are best thought of as a continuum that sets up a gene flow from source to end use. Unless all phases are operating an imbalance or block develops. Continuous flow from phase to phase keeps high yielding varieties on the market; improves the quality of agricultural products; reduces dependence on pesticides, thus enhancing the environment; minimizes cost of production, and reduces vulnerability to pests and environmental stresses.

Society has great concern about the loss of species from the earth. The Endangered Species Act was passed to minimize the loss of species. The Nature Conservancy and other organizations are active in protecting life forms in preserves, zoos, and arboretums and in preventing environmental disturbances that may endanger the habitat of species. This is conservation at the species level. Many endangered species have no detectable use except that they are a part of the great interdependence of life forms in ecosystems. The disappearance of a species might cause an ecological shift unfavorable to esthetic values and even utility.

The NPGRB contends that society should be equally, if not more, concerned about the conservation of the genetic variability accumulated within economic species during the long evolutionary processes. After all, most of these species have demonstrated their usefulness since the dawn of agriculture. People are dependent on them for food, fiber, and some industrial materials for survival and on things of beauty for an enhanced quality of life. We will continue to encounter changing pest problems, changing concepts

of food safety and human nutrition, growth in population, the need to grow crops in more environmentally stressed situations, and use of plants for bio-mass energy.

Plant genetic resources are maintained in four ways: (1) Most are maintained in natural ecosystems according to the "survival of fittest" principle. This material is just out there, with no inventory and no managed preservation scheme. (2) Folk varieties are cultivated generally by small farmers in lesser developed countries where modern professionally bred varieties do not dominate the agriculture. (3) Collections and materials are assembled by private corporations, professional research scientists, private collectors, hobbyists and amateurs. (4) Permanent collections are maintained in the public interest by governments.

Problems with the first two categories have been discussed. The third system is notoriously subject to abandonment, because originally interested curators retire, administrators object to the expense of maintenance, and institutional land and facilities are relocated. The third category also has limited use, because it is difficult to know who has what where, and information on the items is disorganized and inaccessible. Early in its history the United States decided that the first three maintenance categories were not trustworthy enough to provide for the plant resources for the cultivated crop species. The present form of our national scheme for maintaining plant genetic resources is known as the National Plant Germplasm System. The system has evolved over time, particularly since the Research and Marketing Act of 1946 established regional and interregional plant introduction stations with joint Federal and State funding.

## II. RESEARCH AND DEVELOPMENT ACTIVITIES FOR CONSERVING AND USING PLANT GENETIC RESOURCES

### Phase 1. Collect, maintain, evaluate, document, and distribute plant genetic resources.

This phase has received substantial attention by SEA-AR and SEA-CR in recent years. The high priority assigned to this work was stimulated in part by (1) the previously mentioned reports of NAS and ARPAC, (2) the world interest in the issue as expressed by the IBPGR publication, "Priorities among Crops and Regions," (IBPGR was established by the Consultative Group on International Agricultural Research "to insure that genetic variability in economic species of plants is conserved so that it can be used by plant breeders and by research workers interested in the evolution of cultivated plants and of agriculture itself"), (3) the NPGRB established by Secretary's Memorandum No. 1875, dated July 3, 1975, (4) the recommendations of the NPGC, (5) symposia on genetic vulnerability and germplasm resources of the 1975 annual meeting of the Crop Science Society of America, and (6) numerous articles in popular and scientific publications.

Tangible evidence of action includes (1) much better funding and staffing for the NSSL, Ft. Collins, Colorado, (2) a budget item in SEA-AR for plant explorations that allows 6 to 8 expeditions per year, (3) increased support for Regional Plant Introduction Stations and curators of specified germplasm, (4) development of the NPGS, (5) approval of National Research Program (NRP No. 20160), "Introduction, classification, maintenance, evaluation, and documentation of plant germplasm", and of Special Research Program "Genetic Vulnerability", (6) commitment by SEA-AR and SEA-CR to develop facilities, staff, and support for a nationally coordinated system of clonal repositories for fruit and nut germplasm, (7) a cooperative agreement between SEA-AR and LISA, Colorado State University, Fort Collins, for the development and implementation of a computer-assisted information system to service the NPGS, and (8) the SEA-CR competitive grant program on genetic vulnerability.

The NPGRB surveyed the status of germplasm collections in ten crops and found deficiencies in existing collections, inadequate support for official curators of germplasm, and inadequate training of personnel with skills and interest in germplasm biology. Doubtlessly an analysis of other crops would reveal similar deficiencies.

Phase 2. Understanding the genetic variability and geographic distribution of cultivated species and their taxonomic and cytological relationships with closely related species.

Knowledge of the genetic structure of cultivated plants and of their genetic relationships with closely related species is essential for effective planning and execution of plant improvement programs. Concepts of inter-specific relationships are developed from basic studies in many disciplines: genetics, cytogenetics, biochemistry, morphology, distribution, and ecology. Such information is required for the sound and workable taxonomy needed to catalog and use the large number of accessions in germplasm collections.

Genetics. In the study of the genetic architecture of crop plant species, linkage groups are mapped for the most clearly expressed marker genes. Also investigated is inheritance of quantitative and cytoplasmically determined characters. The methods exploit both spontaneous and artificially induced mutations. Studies of cellular genetics promote an understanding of the basic genetic makeup of a plant species and provide genetic lines that have immense potential for solving problems in physiology, morphological development, and plant biochemistry. These investigations are coordinated with studies of inheritance of economic traits visualized in Phase 4 and are inevitably integrated with those of cytogenetics.

Exotic accessions are also studied to determine their crossability with crop species and the characteristics of hybrids that might thereby be produced. These investigations determine the limits of hybridization, the nature of barriers to genetic exchange, fertility and viability of  $F_1$  hybrids and later generations, and the extent of genetic and cytoplasmic differences between the parents. Not only is such information vital to biosystematists, but it also informs the plant breeder of the feasibility of using such accessions successfully.

Cytogenetics. Genetic analysis of a species is aided by coordinating it with the study of chromosomes. The chromosomal composition of a species is analyzed by employing cytological deviations from normal. Wild forms of the cultivated species and related species are routinely analyzed for chromosome number and morphology as aids in understanding natural relationships and the nature of barriers to gene exchange between taxa. Studying the relationship of meiotic chromosome pairing and fertility in diploid and polyploid hybrids often clarifies the nature of hybrid sterility and leads the way to the most efficient use of exotic germplasm.

Maintenance of genetic and cytogenetic special stock collections from economically important crop species is necessary for progress in research. The special stocks are also used in physiological and biochemical studies that are concerned with an understanding of plant growth and developmental processes. A recent NAS-NRC report entitled "Conservation of Germplasm Resources: an Imperative" recommends "that support by the NSF of important genetic stock centers and maintenance of germplasm resources through support from the NIH Division of Research Resources is very helpful and should be continued and expanded. Other agencies should consider adopting the policy of direct support of genetic stocks to assure their continued availability..." Genetic stock collections are uniquely useful as research tools and are not to be confused with the general germplasm collections that provide genetic variability for crop improvement. Currently support of genetic stock centers for crop species is divided between SEA and NSF, with little formal planning or collaboration. It would be desirable for SEA and NSF to review the problem of genetic stock maintenance in order to develop a policy of financial support adequate to the task. Such a policy might involve either transfer of funds or reassignment of responsibilities for certain stock centers.

Biochemistry. The literature has many examples of the use of biochemical constituents for studies of the classification and evolution of plant species. For example, differences in terpene content are of systematic interest in the pines as are storage proteins in the legumes. Besides aiding systematists, such determinations may reveal new sources of compounds with nutritional or industrial significance. The degree and pattern of variability of isozymes have already permitted analysis of interspecific and subspecific relationships. The nature of pest resistance, food safety, and nutritional quality are largely determined biochemically.

Morphology. Morphological characters furnish the data for classical taxonomy and often provide the only criteria for classification of herbarium specimens and field identifications. Qualitative characters are observed and quantitative characters are measured in the form of the whole plant or its parts. In plant germplasm assemblages the collection of such data is usually limited to characters of systematic and economic importance, but studies integrating morphology with the genetics are mutually beneficial.

Distribution. Information concerning geographic distribution often directs collectors to critical areas and distinguishes between wild and domesticated traits. The area of cultivation usually extends far beyond the native range; such differences can be significant in relation to the presence or absence of pests. Geographic isolation frequently expedites the differentiation of new biotypes and thus can be important in plant collecting expeditions.

Weedy races may accompany the cultivated forms and play a significant role in the evolution and use of plant species.

Ecology. The distribution of a plant taxon is determined by its ecological preferences. Reproductive isolation can play an important role in evolution and thus be of interest to the systematists. Observations of the responses of plants to temperature, light intensity, photoperiod, soil type, and other factors in their native habitats and in first-trial plantings can give important information for the effective use of plant germplasm resources.

Continued research in these areas can provide the following benefits: (1) Determine the nature of genetic control of certain characteristics of interest to plant breeders, (2) reveal the opportunities and limitations of gene transfers from accessions to acceptable cultivars, (3) yield clues on the presence of useful characters, (4) ascertain the origin and sites of domestication, and (5) formulate a sound basis for classification.

Phase 3. Screen plant genetic resources for specific, desirable characteristics.

As plant genetic resources are collected or produced, they need to be screened to determine what characteristics they possess that are desirable for agriculture. As characteristics are identified, the germplasm is used as parental material for developing new genetic complexes. Each variety or population is characterized by a specific genotype or gene frequency. When crosses are made between strains of divergent origin, the  $F_1$  generation may exhibit hybrid vigor and the  $F_2$  generation of such hybrids may display genetic variability caused by the recombination of genetic material in new and unique genotypes. This provides further opportunity for the isolation of more efficient and desirable types.

Indepth screening is done by the users rather than the maintainers of the plant genetic resources. The potential value of germplasm collections depends upon the efficiency of techniques available or still to be developed that are designed to characterize the genetic differences among the individual items of a collection.

Ideally indepth screening should be done by crop-improvement teams made up of breeders, entomologists, pathologists, and soil scientists. Because of close ties with farmers, such a team would be aware of problems arising from an outbreak of a new pathogen or race or a new destructive insect. They could identify the causal agent involved and establish either the suitability of existing inoculating techniques or, if necessary, devise and evaluate new procedures. Such a team should have the field and laboratory facilities and the crop expertise necessary for success. The procedures necessary in any search for resistance are likely to be required to transfer such resistance to commercially useful varieties.

This team approach has a long history of success in discovering sources of resistance, for example, downy mildew in corn, the corn viruses, the several smuts and rusts of small grains, late blight in potatoes, spotted

alfalfa aphid, and many others. Within the past 40 years the improvements in pest resistance of our major cultivated crops have been an important factor in increasing efficiency of our agricultural production.

Germplasm may also be screened for attributes other than disease or insect resistance. Possible attributes include: morphological variations contributing to increased yield; variation in quantity and quality of proteins, amino acids, or fats; the absence of toxic substances such as trypsin inhibitor in soybeans. Such a list could be extended indefinitely. Screening for desirable attributes of the type listed may require specialized equipment. Fortunately both apparatus and techniques are available for measuring many attributes of interest. Few of the procedures now available, however, have the capability or flexibility for handling the large numbers required for effective progress.

Phase 4. Study the genetic mechanisms controlling the inheritance of desirable characteristics.

The discovery of desirable characteristics in the screening phase is the first step in the use of the germplasm resource. If an effective strategy for using specific characters is to be developed, genetic analysis of the inheritance of specific traits and the quantitative analysis of population variability are essential prerequisites.

Breeders are urged to select various objectives by soil scientists, nematologists, pathologists, entomologists, and physiologists as well as farmers, food scientists, trade associations, processors, and consumers. Breeders face a bewildering choice of potential parental materials, and the science of plant breeding offers many breeding methods. If a good choice of objectives, materials, and methods is to be adopted, information is needed on the inheritance and genetic variability of desirable traits.

Phase 5. Combine genes from diverse sources into improved strains more useful to plant breeders.

Genes for desirable characteristics are usually found in stocks unsuitable for cultivation. Resistance to pests, ability to stand cold or drought, high protein content, improved amino acid balance, early maturity, and a host of other desirable features are seldom found together in stocks as an ensemble of the characteristics required for successful cultivation. Successful varieties have to have a composite of characteristics that makes them more profitable to grow than varieties already on the market. Building insect and disease resistance into superior varieties, a continuing struggle of science against nature, requires long-term, continuous work by competent entomologists, pathologists, and breeders. Such work is sometimes called developmental breeding, or exploratory research. This work connects germplasm collection, screening, and genetic analysis with applied breeding. From a large number of objectives that might be pursued, it sorts out those that have a high probability of success. It prevents the more applied programs from diverting their limited resources and time into unproductive efforts.

The work of the first four phases produces breeding materials that possess unique characteristics or unique combinations of genes with reasonably good agronomic or horticultural features. It is becoming more and more common for Federal and State agencies to release improved breeding stocks noncommercially so that applied breeders from any public, private, or lesser developed country may use the material at this stage.

Adaptation, or its lack, becomes an important problem in the transfer of desired traits from an exotic or wild strain to a commercially useful variety. Even though the genetic basis of the desired trait may be simple, the combination of specific characteristics with all other genetic traits affecting adaptation and field performance may result in a very complicated genetic system. The degree of complexity varies with the degree of dissimilarity of the parents used. Here, again, it appears that evaluation as well as screening can best be accomplished by a crop improvement team. It is in this phase that the recurrent evaluation of resource material being advanced toward cultivation becomes of utmost importance.

Evaluation of the relative merits of candidate strains and varieties is most often based on the results of a series of replicated performance trials over a period of years at several locations. The material is subjected to a sample of the environments that future varieties are most likely to encounter. This includes variation in soil type, nutrition levels, diseases, pests, weather, cultural practices, and harvesting methods. Although this type of field evaluation is still the best predictor of the future performance of any new variety, scientists often resort to evaluations in controlled environmental conditions. This is done to reduce the tremendous variation in weather and infestations that nature provides. For example, estimates of disease resistance are more reliable from artificial inoculations than from natural field conditions. Cold tolerance may be investigated in a temperature-controlled greenhouse or growth chamber.

Phase 6. Breed, release, and maintain breeder seed of varieties and stocks of improved germplasm.

The germplasm resource base for any crop involves a diverse assemblage of materials which may be roughly grouped as follows: (1) Currently useful varieties, (2) the very sizable reservoir of adapted but not currently utilized materials, (3) exotic and usually unadapted materials, and (4) the wild and weedy relatives. The problems relating to use increase in complexity with this progression. Plant breeding progress is most readily achieved when efforts can be confined to materials in groups one and two. Necessity, however, may require the use of materials from groups three and four.

Varieties are basically improved through a system of germplasm resource management. However, the majority of plant breeding experience and its foundation in quantitative genetic theory is based on studies with varieties and other adapted materials. The use of exotic and wild material poses a number of special problems for which neither theoretical nor practical answers are adequate. Recently funds for collecting and maintaining germplasm have been increased. These are necessary endeavors; however, if we are to

move from a museum type of activity to one that recognizes vigorous utilization, adequate continuing support must be provided for crop improvement.

Crop yields in the United States over the past 45 years (1930-1975) have been remarkably upward. The following table shows the average yields of some field crops and major vegetables, as recorded in Agricultural Statistics, U.S. Department of Agriculture. The percentage increases from the original values range from 33 to 413 percent or about 1 to 9 percent per year on the average.

Average Yield Per Acre

	<u>1930</u>	<u>1975</u>	<u>Unit</u>	<u>Percent increase</u>
Wheat	14.2	30.6	Bushels	115
Rye	12.4	22.0	Bushels	77
Rice	46.5	101.0	Bushels	117
Corn	20.5	86.2	Bushels	320
Oats	32.0	48.1	Bushels	50
Barley	23.8	44.0	Bushels	85
Grain Sorghum	10.7	49.0	Bushels	358
Cotton	157.1	453.0	Pounds	188
Sugarbeets	11.9	19.3	Tons	62
Sugarcane	15.5	37.4	Tons	141
Tobacco	775.9	2011.0	Pounds	159
Peanuts	649.9	2565.0	Pounds	295
Soybeans	13.4	28.4	Bushels	112
Snap beans	27.9	37.0	Cwt	33
Potatoes	66.0	253.0	Cwt	283
Onions	159.0	306.0	Cwt	92
Tomatoes:				
(Fresh market)	61.0	166.0	Cwt	172
(Processing)	4.3	22.1	Tons	413
Hops	1202.0	1742.0	Pounds	45

A graph of average annual yields for each crop would have many ups and downs, influenced primarily by the weather; however, the trend has been steeply upward. Some crop yields are apparently beginning to plateau. Consumer demands require that we achieve equivalent or better gains in the next 45 years. Increased research on the biological processes of plants and plant pests is required to put genetically superior crops in the field and protect them against pests and environmental stresses.

Factors influencing the yield of a modern crop variety are complex. Fundamentally, yields per unit input of land, labor, and energy can be increased by breeding and crop management. The proper integration of genetic potential with insect and disease control, weed control, use of fertilizer and irrigation, timely and efficient cultivation and harvest, and other management activities are essential to continued yield increases. As crop production systems increase in complexity, genetic yield potential must keep

pace. However, the genetic diversity must also be broad enough to avoid losses from pest outbreaks and to minimize the effects of annual weather fluctuations. The weakening of a single component may greatly depress overall yields, as illustrated by the corn blight situation in 1970.

Phase 7. Produce high-quality planting seed and distribute it to farmers.

This final phase of germplasm resources management has increasingly become a function of the commercial seed industry. The function of the seed trade is to supply farmers with an uninterrupted source of improved, high-quality planting seed. Some segments of the industry also support extensive breeding programs and thereby contribute to the objectives outlined under phases 5 and 6. However, the industry is not in a position to assume responsibility for many of the fundamental research objectives of germplasm management described in phases 1 through 4. On the contrary, the research efforts of industry have been and are likely to continue to be concentrated in those areas of practical plant breeding designed to produce the maximum number of commercially acceptable varieties in a minimum amount of time. To provide answers to fundamental breeding questions, increased support of the public research institutions is essential.

The cooperation between the public institutions engaged in the genetic manipulation of plant germplasm and the private seed industry is unique to the United States. Over the years the two groups of organizations have arrived voluntarily at a logical division of labor that includes minimal duplication of effort. The complementary nature of the relationship has served American agriculture well. The need for this kind of cooperation is as great today as at any time in the past. Each crop improvement program of industry and the public agencies does not need all seven phases; the nation itself needs all phases. This program can be a model for the national sharing of the workload among State and Federal agencies and private industry.

### III. RESEARCH PRIORITY FOR PLANT BREEDING

In a recent "white paper" entitled "Research Priorities in Plant Breeding," Sprague, Alexander, and Dudley emphasized that successful plant breeding feeds the world. Recently, planning reports and the popular press have suggested that proven plant breeding methodologies will be replaced by genetic engineering. The "white paper" states that:

1. Classical plant breeding has been successful.
2. The limits to crop improvement through classical plant breeding have not been attained.
3. The heritable variation necessary for long-term improvement exists in our crops.
4. Effective utilization of variation requires a plant breeding approach.

5. Genetic engineering is a potentially useful tool that must have concurrent use of plant breeding techniques if it is to be effectively applied.

The broad field of genetic engineering now receives a high priority rating. The field holds some promise and unquestionably deserves support. The high priority rating is questionable, however, if the research is to be achieved through neglect of those disciplines that continue to improve plant performance and offer promise for the future. Even if new products are developed by genetic engineering techniques, the use of them will be accomplished through conventional crop improvement programs. Continuing progress in improving the performance of crops cannot reasonably be expected unless this relation is understood and implemented.

Budget justifications for plant breeding encounter difficulties. The plant breeding effort is shared by State, Federal, and private enterprise, and the work is scattered geographically and fragmented by commodities. Budget proposals look too much like "shoring up" of old programs that has been given the lowest of priorities recently. Plant breeding does not enjoy any trendword popularity, and component parts of the total system are often rated out of context.

Since the term "genetic engineering" has been coined, claims have continually been made that new techniques developed in the prokaryotes (bacteria, viruses)--for example, cell culture, protoplast fusion, and plasmid modification and transfer--hold great promise for both plant and animal improvement. These claims have been accepted by some and accorded a higher priority in research funding than that given conventional methods of breeding.

Uncritical acceptance of the potential importance of the new "genetic engineering" techniques, requires the denial of one or more of the following facts:

1. Efficiency of crop production is of short-term importance to American agriculture; the agricultural applications of genetic engineering are admittedly long range.
2. Plant breeding has made, and continues to make, genetic advances in crop productivity and quality.
3. Past successes in plant breeding have not exhausted genetic variability to the point that little progress can be anticipated in the future; much useful variability exists in domestic and exotic germplasm.

#### IV. CROP COMMITTEES

During recent decades, massive resources have been directed to support the improvement of the major food commodities worldwide. Support of a network

of 10 international agricultural research institutes, most organized on a crop or animal commodity basis, has increased from about \$15 million in 1972 to about \$90 million in 1978. Concurrently, a number of foreign national agricultural research systems have been strengthened at an annual cost several times that invested in the international institutes; most of them also are organized on a commodity basis. Most receive substantial financial support from the United States, either directly through USAID or indirectly through the international banks. Most international agricultural research is organized around commodities; for the United States to be informed and influential about developments abroad, we should have strong commodity committees comprising authorities in plant breeding, plant pathology, entomology, and other relevant fields.

The United States should develop a cadre of national and international commodity experts in USDA and the State systems. Such individuals should have wide knowledge to keep the United States at the forefront of international efforts.

There should be a separate national committee for each crop or group of crops of significance to American agriculture. SEA, USDA could provide control leadership and support. In most cases the committee leader should be a plant breeder or geneticist of high national standing. The mandates of each committee should include:

1. Development of a strategic overview of progress in the United States with each commodity identifying strengths and weaknesses of the national scientific efforts on that species and recommending means of organizing activities that would benefit from national cooperative work. Particular attention should be given to plant breeding and genetics and to activities on disease and insect resistance and other means of pest control.
2. Development of an ever-improving understanding of foreign scientific developments on the crop in question identifying and describing implications for science and agriculture in the United States.
3. Providing periodic reports on national and international developments with the species, with statements of implications for the United States and recommendations for strengthening work, either in this country or in institutions abroad receiving major support from this country.

#### V. PERSONNEL REQUIREMENTS

Qualified scientists are needed to estimate the U.S. manpower requirements in germplasm biology. Current estimates of national need are lacking in the private and public sectors. An estimate of manpower requirements has been made by and for the USDA, but this estimate is for such broad categories as "soil scientists," "plant pathologists," and "agronomists." It does not delineate the proportion required within any group for germplasm biology.

The needs must be identified for the private, public, and possibly international sectors. Estimates should be compiled for the near future (5-10 years) and for the long term (more than 10 years). This documentation should include areas of germplasm biology that are of current critical importance (e.g., host-parasite biology, population biology, cytogenetics, evolution, breeding methodology) and of potential importance (e.g., cellular and sub-cellular biology of flowering plants, cell and tissue culture, viral transfer of genetic material).

Research program development in the United States accelerated immediately after World War II. Many of the scientists recruited at that time are now reaching retirement age. Many changes in personnel must take place during the next 10 years. The present time is therefore critical for reviewing manpower requirements and for reconsidering program priorities at all levels. In spite of the expansion of research during the past 30 years, the current output of qualified personnel may not be adequate to meet the needs of the near future. The number of training centers, particularly in plant genetics, has diminished, and the possibilities of extinction in certain areas of expertise are real.

#### VI. FUTURE OF NPGRB AND ITS REQUIREMENTS

The NPGRB should:

- (1) Identify relevant research areas needing funding.
- (2) Suggest how regulatory agencies responsible for detecting breakdowns in agricultural systems might more efficiently meet national needs (e.g., detection of potential disease epidemics in the United States and abroad).
- (3) Help develop guidelines on the competitive grants program.
- (4) Serve as a principal arm for the Secretary in studying germplasm resources and in recommending use of breeding material, thereby helping to insure that appropriate measures are taken to avoid catastrophes caused by narrowing the germplasm base during the improvement of crop plants.
- (5) Change its membership in a regular and systematic way in order to bring fresh ideas and new experience to the task.

To accomplish its purposes the NPGRB should be assured of an existence long enough to meet the objectives so urgently needed by the nation. The operations of the NPGRB would be greatly enhanced if it had the services of a fulltime, permanently assigned Executive Secretary with clerical staff and a budget sufficient for travel, publication costs, and occasional conferences or symposia.

## Technological Objective 2

Increase understanding of taxonomic, cytological, cytogenetic, and biochemical relationships among plant genetic resources. This technological objective also cross-references to NRP 20160, Plant Germplasm. This technological objective goes much beyond the taxonomic nomenclature of plants. It includes knowledge of chromosome number, chromosome pairing and fertility of hybrids as well as genetic structure and genetic variability of species over two geographic ranges of their distribution. Knowledge of the genetic structure of cultivated plants and of their genetic relationships with closely related species is essential for effective planning and execution of plant improvement programs.

### Research Locations:<sup>2/</sup>

5205 Salinas, California  
1211 Washington, D. C.  
3311 Urbana, Illinois  
3302 West Lafayette, Indiana  
3408 Ames, Iowa  
1100 Beltsville, Maryland  
3402 Columbia, Missouri  
3705 Lincoln, Nebraska  
7803 Oxford, North Carolina  
7802 Raleigh, North Carolina  
3602 Fargo, North Dakota  
7317 Stillwater, Oklahoma  
1302 University Park, Pennsylvania  
7711 Charleston, South Carolina  
7302 College Station, Texas  
5702 Logan, Utah  
3507 Madison (Sturgeon Bay), Wisconsin

2/ Other sites to some degree.

### Selected Examples of Recent Progress:

Cross-referenced to NRP 20160

## Technological Objective 3.

Improve the national program to utilize plant genetic resources for the breeding of cultivars and breeding stocks with increased genetic potential for producing high yields of good quality products with minimum losses from pest and environmental stresses.

### Research Locations:<sup>3/</sup>

3/ To list research locations for this technological objective would be to list all those stations where plant breeding (Code 0512) in PARIS and

CRIS is performed. A PARIS printout as of October 1977 is available; however, it does not seem useful to report the whole program here.

Selected Examples of Recent Progress:

Cross-referenced to the following NRP's:

- 20010 Fruits, nuts & specialty crops production
- 20020 Vegetable production
- 20030 Florist & nursery crops production
- 20040 Corn, sorghum & millet production
- 20050 Small grain production
- 20060 Cotton production
- 20070 Tobacco production
- 20080 Oilseeds production
- 20090 Sugar crops production
- 20100 Forage crops production
- 20110 Range management
- 20170 Physiology & biochemistry-plants

Technological Objective 4.

Develop improved methods for control and management of pests.

Research Locations:

Cross-referenced to the following NRP's:

- 20220 Insect control-horticultural crops
- 20230 Insect control-cotton & tobacco
- 20240 Insect control-field crops
- 20250 Insect control-basic/non-commodity
- 20260 Bio-control & insect identification
- 20270 Disease & nematode control-crops
- 20280 Weed control
- 20290 Pesticides & growth regulators

Cross-referenced to SRP's:

Pilot testing of alternative methods  
for pest control  
Minor use pesticides



